DEVELOPING METHODS

Goal: Increase effective methods available for wildlife disease management.

BIRD RESEARCH PROGRAM

Title: Economic Impact and Management of Bird Predation at Aquaculture Facilities in the Southeastern United States

Goal: Determine the magnitude of and develop methodology to reduce damage by cormorants, wading birds, and pelicans on southern catfish, baitfish, and crawfish farms.

Double-Crested Cormorant Satellite Telemetry—Populations of double-crested cormorants have increased dramatically during the past 2 decades and are causing more and more problems throughout their range. NWRC scientists initiated two studies to investigate the continental movements of double-crested cormorants in North America. One study involved attaching 25 satellite transmitters to cormorants adjacent to catfish aquaculture facilities in Alabama, Arkansas, Louisiana, and Mississippi. Results from that study will identify the northward and southward migratory paths of cormorants captured near southern aquaculture facilities. The second study was initiated on the cormorant breeding grounds and will determine the effectiveness of breeding-colony control activities at Little Galloo Island, NY, in eastern Lake Ontario. The foraging distribution and subsequent migratory behavior of these breeding cormorants will also be analyzed using a geographical information system.

Great Blue Heron Foraging Ecology and Disease Transmission— Researchers at NWRC's Starkville, MS, field station completed several studies that investigated heron foraging behavior in relation to fish disease ecology. The studies demonstrated clearly that foraging by great blue herons at catfish farms was greatest in ponds with diseased fish or where fish were being fed with floating feed. Heron populations on catfish farms were relatively low during spring and late winter, and predation on catfish was directly related to outbreaks of fish disease in fall (September–October). Thus, catfish farmers can reduce losses by dispersing herons from feeding ponds only during the summer months (July–August) and only when fish are being fed.

American White Pelican Foraging Ecology and Demographics— Although populations of American white pelicans are an increasing concern to aquaculturists in the Southern United States, the fundamental ecology of this species remains poorly understood. Scientists at NWRC's Starkville field station have been monitoring pelican populations in Louisiana and Mississippi since 1993 and have been banding American white pelicans at predominant breeding colonies in North Dakota and Minnesota since 1996. On the pelican's winter range in the South, NWRC scientists have investigated American white pelican food habits, constructed daily activity budgets, monitored daily and seasonal movements, and documented the population status and habitat use. The results of these studies will increase the knowledge of the impact of American white pelicans on southern aquaculture and provide a basis for future management actions. To supplement these efforts, NWRC scientists initiated research at the breeding colony at Chase Lake, ND, in July 2000 that will provide information on age-specific survivorship and fecundity.

Wading Bird Impacts to Bait Fish and Catfish Production— Scientists at the Starkville field station completed a field evaluation of the impacts of great blue herons, little blue herons, and great egrets on baitfish production and a survey of all baitfish farmers in Arkansas to determine the spatial and temporal patterns of bird depredation to their industry. In the field study, 83 to 94 percent of the wading birds collected on baitfish aquaculture facilities were determined to be immature birds, indicating that nonlethal dispersal of rookeries might deter wading bird predation. A pen study with captive birds further investigated the foraging ecology of great egrets and their preference for catfish fingerlings in various size classes. The results of these studies will help baitfish farmers evaluate the impact of bird predation on their facilities and devise cost-effective management strategies.

One-third of known baitfish facilities in Arkansas were surveyed about the major factors affecting aquaculture production losses, bird species that are seen at each facility, timing and extent of depredation, and techniques used by the fish farmers to minimize bird-caused losses. Fish-eating birds were identified as the main cause of production losses by 65 percent of farmers responding to the survey. A more complete description of the survey results can be found in Werner, S.; Wooten, D. 1999. "Fish-eating bird impacts in Arkansas: where and when?" Aquaculture Magazine 25(6): 70–72.

Title: Development of Methods To Manage Depredation and Nuisance Problems Caused by Vultures

Goal: Understand the relationships between various habitat and land-use variables and problems caused by vultures and develop effective management techniques for reducing predation losses and property damage.

Management Methods To Reduce Vulture Predation on Livestock— Predation on newly born livestock by black vultures has increased steadily in recent years and has been reported to WS personnel in at least 15 States. To address this depredation issue, NWRC scientists initiated a study to determine what factors of cattle management and vulture behavior contribute to predation of newborn calves. The study is concentrating on whether vultures from nearby roosts are responsible for livestock predation and if dispersal of these roosts will eliminate or reduce the problem. The distribution of predation events with respect to age of the cows is also being examined.

Biologists at NWRC's Gainesville, FL, field station monitored vulture activity in Florida on 34 days during January through March 2000 to quantify the interactions with cattle. Observations to document vulture use and to identify possible risks to calving herds from vultures were made in 15 of 38 pastures that had a variety of heifer (first-time breeder), cow, and calf combinations. During 290 counts, 543 vultures were seen in the pastures. Of those, 78 percent were turkey vultures, and 22 percent were black vultures. The largest number of turkey vultures was observed in pastures with heifers and calves, while black vultures were nearly evenly divided among pastures containing heifers only, heifers and calves, and cows and calves.

In 92 percent of the observations, the birds posed no immediate threat to cows or calves. About 4 percent of the vultures were observed eating or foraging in manure. No predation activity by vultures on livestock was observed. A number of dead calves and cows were observed in pastures, but it was not possible to determine the cause of death.

During an additional almost 60 hours of observations of vultures in pastures, observers noted one attempted depredation by black vultures on a calf as it was being born. The cow was able to chase the birds off, however; and the birth proceeded successfully.

The documentation of vulture activity will result in better understanding of the use of calving pastures by vultures. That understanding will lead to management recommendations enabling ranchers to more effectively protect their newborn livestock.

Title: Development and Evaluation of Management Techniques for Reducing Blackbird Damage to Ripening Sunflower Crops and Feedlots

Goal: Develop new and/or improved methods to reduce blackbird damage to ripening sunflower crops and to feedlots.

Habitat Characteristics of Spring Blackbird Roosts in Eastern South Dakota—Biologists from NWRC's Great Plains field station in Bismarck, ND, and cooperating scientists have developed a cartographic model to help predict the location of spring migratory blackbird roosts in eastern South Dakota. During 1998 and 1999, habitat characteristics of blackbird wetland roost sites located in nine counties were described from aerial photos analyzed with geospatial computer software. Major roosts (>50,000 birds) typically exceeded 75 ha and were more than 50 percent covered by cattails. These wetlands were often located on public lands that had artificially regulated water levels.

National Wetland Inventory data and land-use data were used to develop a cartographic model predicting regions in eastern South Dakota where blackbirds are likely to occur. The model predicted that the majority of the spring roosts would be located in the southern Prairie Coteau ecoregion. This model will help biologists locate spring-migratory blackbird roost sites in eastern South Dakota before numbers of such roosts peak.

Bird Use of Ripening Sunflower Fields in North and South Dakota—NWRC and cooperating scientists jointly conducted intensive bird surveys in fall 1999 in eight counties in North Dakota and South Dakota. The objective was to document nontarget birds that might be negatively affected by pesticide baiting programs, particularly applications of DRC–1339-treated rice. The scientists observed birds at 15 rice-baited plots, each located within 75 m of a wetland. During more than 100 hours of observations, 18 bird species were seen in the plots. Scientists observed 10,780 birds, of which 91 percent were red-winged blackbirds, 7 percent were yellow-headed blackbirds, and about 1 percent were mourning doves, common grackles, or sparrows. Many of the nontarget birds were observed near tree rows and wetlands, indicating that DRC–1339 baits should be placed away from such locations.

Blackbirds and Sunflowers—During fall 1999, personnel from North and South Dakota WS and NWRC's Bismarck field station interviewed sunflower producers to obtain information about blackbird damage control options. In North Dakota, 211 sunflower producers from 34 of 53 counties were interviewed. Of these, 81 percent reported using at least 1 nonlethal method to disperse blackbirds from sunflower fields, 42 percent employed 2 or more nonlethal techniques, 86 percent dispersed blackbirds by shooting, and 55 percent used gas exploders. Avitrol®, a chemical repellant, was used by 4 percent of the producers. Six producers had previously utilized WS cattail-management methods to reduce cattails and make their property less attractive to roosting blackbirds.

In South Dakota, 20 producers from 12 counties also were interviewed relative to blackbird damage management. Of those responding, 60 percent used shooting as a dispersal method, and 40 percent used gas exploders, pyrotechnics, or electronic frightening devices. Also, 60 percent of the producers utilized at least 1 nonlethal method, and 30 percent used at least 2 nonlethal management techniques.

Title: Management of Bird Damage to Rice

Goal: Develop new or improved management strategies for reducing bird damage to rice.

Flight Control™ Shows Promise as a Blackbird Repellant for Newly Planted and Ripening Rice—An important NWRC research priority is the development of a blackbird repellant that will reduce damage to newly planted rice seed and ripening rice. Researchers have evaluated several chemical compounds through a systematic series of chemical screening, laboratory tests, and field evaluations aimed at registration of a selected repellant with the Environmental Protection Agency (EPA). Some repellants (such as Mesurol®, methyl anthranilate, and lime) were effective at different stages of testing but failed to be effective overall or were not economical and/or environmentally safe.

One potentially useful compound that has shown promise is anthraquinone. It is the active ingredient in Flight Control, a product produced by Environmental Biocontrol International and registered with EPA as a bird repellant for Canada geese on turf. Field tests of Flight Control on newly planted rice from 1998 to 2000 in Louisiana have indicated that the product can significantly reduce blackbird damage to newly planted rice. Chemical residues remain effective through the plants' susceptible stage but fall off dramatically thereafter. Preliminary results suggest no chemical residues in the mature seeds.

Flight Control has also shown some promise as a blackbird repellant for headed rice. Field tests have shown that Flight Control sprayed at about 19 L/ha over ripening rice reduced blackbird use of treated rice fields dramatically for 3 to 7 days. Large-scale testing under an experimental use permit is planned in FY 2001.

Improving DRC–1339 Acceptance— Blackbird damage to newly planted rice is an economically important problem for many producers in Arkansas, Louisiana, Missouri, and Texas. DRC–1339 rice baits, an avicide used on staging areas to manage blackbird populations prior to rice planting, are rejected by blackbirds when baits have been exposed for more than 12 hours. To improve acceptance of DRC–1339 baits, NWRC researchers are comparing blackbird acceptance of untreated brown rice baits to various tablet DRC–1339 baits that mimic some of the characteristics of brown rice. DRC–1339 tablet baits were formulated in 12-mg and 18-mg sizes, containing 60 percent brown rice flour mixed with or without calcium, in different colors (white, light grey, and yellow). All tablet baits contained >1 percent DRC–1339. There was little to no discoloration of these formulated DRC–1339 rice tablets for up to 7 days, whereas DRC–1339/Alcolec–S-treated brown rice turned a bright rust-brown color within 1 day of exposure.

Of the tablet combinations, light grey, 12-mg tablets containing calcium were the most preferred by red-winged blackbirds and brown-headed cowbirds. In cage tests using male and female redwings and cowbirds, this tablet diluted at 1:25 with untreated brown rice achieved 90-percent mortality. The use of a tablet bait could help to eliminate bait aversion and bait discoloration and increase the effectiveness of DRC–1339 baiting programs to reduce damage by blackbirds.

Rice Farmers Association Supports DRC–1339 Confined Rotational Crop Study for Blackbird Staging Area Label—Since 1989, the WS program has been using brown rice baits treated with DRC–1339 on blackbird staging areas to manage blackbird populations that cause damage to newly planted rice. On March 15, 1995, EPA granted a Federal Section 3 registration for terrestrial nonfood uses of DRC–1339 concentrate in staging areas. However, the registration restricted the use of DRC–1339 on land used for growing crops by imposing a 1-year fallow period following any application of DRC–1339. In many States, such as Louisiana, the Dakotas, and Texas, this restriction has had a major impact on the effectiveness of the blackbird management program by severely reducing the areas that could be baited.

Before any changes to the label could be made, EPA required that a C14 Confined Rotational Crop Study be completed. A confined rotational crop study requires that residue levels from the parent compound, in this case CPTH, be determined in three types of crops (a grain, root, and leafy vegetable) over preset plant-back intervals. Louisiana rice growers selected rice, carrots, and soybeans as the representative crops. Since DRC–1339 is used in other wheat-producing States, such as the Dakotas, wheat was also included as a representative crop.

EPA's guidelines require that residues from the parent compound be less than 0.01 parts per million (p/m) in the mature crop. The distribution of DRC–1339 residues from mature harvest samples of wheat were 0.003, 0.009, and 0.007 p/m at 15-, 30-, and 60- day plant-back intervals; soybeans were 0.013 and 0.002 p/m at 30- and 60-day plant-back intervals; and carrots were 0.006 p/m at 30- and 60-day plant-back intervals. Rice residue measurements were similar to those for wheat. Of note, most of these residue levels were below EPA's established level 0.01 p/m. In addition, these DRC–1339 residues were "bound residues" or residues that could not be extracted from the mature seed through an acid wash. These data have been submitted to EPA for its review to support proposed label changes for the use of DRC–1339 in staging areas.

Title: Defining and Reducing Wildlife Hazards to Aviation

Goal: Provide a scientific foundation for WS programs at airports throughout the United States to reduce wildlife hazards to the aviation industry.

Aircraft Collisions With Gulls Reduced at a Northeastern Airport, 1991–99—In 1999, the WS program successfully completed its ninth year of assistance at an airport in the Northeast in a program that has annually reduced laughing gull collisions with aircraft by 76 to 92 percent compared to baseline years, 1988–90. Strikes by other gull species were reduced 48 to 76 percent over the same time period. In this joint operational and research program, biologists have removed 56,000 laughing gulls and 6,000 other gulls at the airport. During this time, the nearby nesting colony on Federal land that is the source of the bird strike problem has declined by about 65 percent, from 7,600 nests in 1990 to 2,720 nests in 2000.

An analysis of data from leg bands recovered from 610 gulls shot at the airport indicated that many gulls hatched in colonies 60 miles or more away have immigrated to the colony next to the New York airport to nest as adults. Because many Atlantic coast colonies of laughing gulls have been increasing, there has been a large cohort of birds available to replace the birds that have been removed. Therefore, an annual shooting program at the airport, while effective in reducing the number of gull–aircraft collisions, has not eliminated the nearby nesting colony or caused a decline in the regional breeding population. A long-term alternative to shooting would be a program of harassment, habitat alteration, or nest destruction at the colony site itself to relocate the colony away from the airport. However, a relocation program has not been possible because the nesting colony resides on a fully protected wildlife refuge.

Laughing Gull Census—Biologists from the NWRC's Sandusky, OH, field station, with assistance by WS State personnel and other State and Federal employees in the Northeast, conducted a ground truth census in June 2000 of the laughing gull nesting colony in a marsh complex totaling 600 acres. The marshes are on federal property adjacent to an airport where gull–aircraft collisions have been a serious problem. The researchers established seven 100- X 100-foot plots in the marshes in which all gull nests were counted. Plots contained an average of 20 nests, indicating a density of about 85 nests/acre in the colony marsh areas. A series of 32 overlapping aerial photographs were taken of the entire marsh complex 2 days after the ground-truth plots were established. A nest census of the entire marsh was obtained by counting all nests, including those in the ground-truth plots, on the enlarged photographs. Counts on the photographs of the ground-truth plots determined the accuracy of the aerial census. Results of the census indicated the colony contained about 2,720 nests in June 2000, a decline of 65 percent from the 7,600 nests counted in 1990. Management programs by WS in the local area in 1991 through 2000 have reduced laughing gull–aircraft collisions by more than 90 percent compared to 1988–90, when the airport averaged more than 150 strikes/year.

Although the local population of laughing gulls next to the airport has declined as a result of these management actions, the regional population from Virginia to Maine has shown no decrease during the 1990s, based on analysis of North American Breeding Bird Survey data. This NWRC-developed census technique is a critical component of the gull management program and may be of use in other situations where colonial-nesting waterbirds conflict with human activities.

Title: Waterfowl as Disease, Parasite, and Noxious Weed Reservoirs in Urban and Agricultural Landscapes

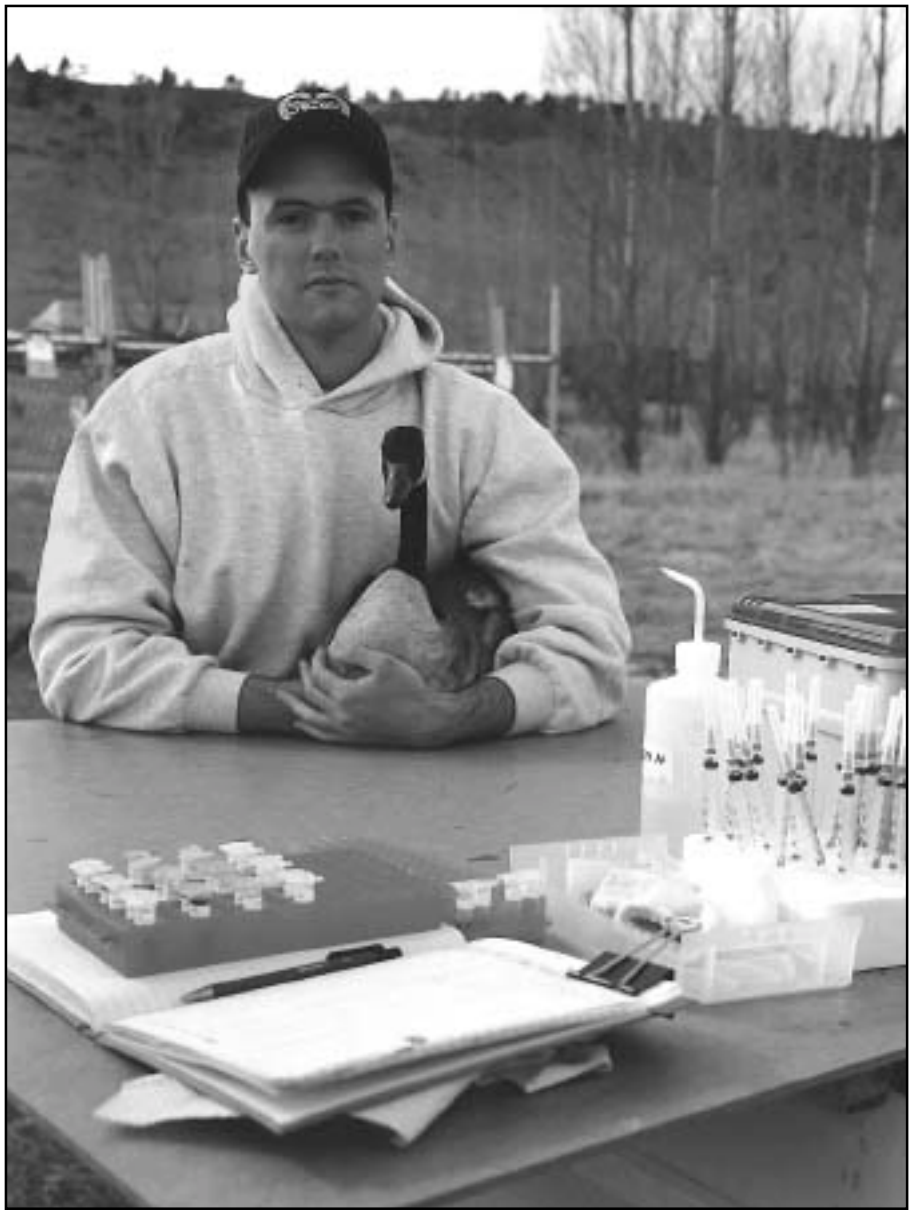
Goal: Understand and develop management recommendations related to the contribution and impact of Canada geese as vectors for disease, parasites, and noxious weeds on human health and safety in urban landscapes and on animal health in agricultural landscapes.

Urban and suburban Canada goose populations are found on golf courses and soccer and football fields, in parks, at residential and commercial developments, and on ponds, lakes, streams, and other waterways. Goose fecal deposits raise health concerns wherever large numbers of geese are found, yet there is no baseline information regarding human health risk factors.

In 1998, NWRC scientists sought to address this lack of information when they initiated studies to identify the prevalence, in Canada goose feces, of two types of bacteria that may cause disease in humans, *Escherichia coli* and *Salmonella* species.

Scientists found the prevalence of *Salmonella* spp. to be extremely low: less than 1 percent of the samples. However, 37 percent of the 393 fecal samples taken over a 12-month period tested positive for *E. coli.* The number of positive cultures was higher for the warmer months. When the temperature was above 50 °F, the number of samples that tested positive for *E. coli* was 82 percent. When temperatures were below 50 °F, the number was 17 percent.

Many types of *E. coli* exist, and several of them can cause disease in humans. Some strains of *E. coli* found in wildlife can be transmitted to humans. However, to show cause and effect in transmission of actual disease from wildlife to humans definitively, one must show that the *E. coli* found in both organisms are identical and have the same toxin or toxins.



To identify risk factors better, scientists performed a more detailed analysis on subgroups of *E. coli,* known as the O serogroups, specifically those associated with human intestinal illness. Of the goose fecal samples taken March–July 1998, 28 percent contained these serogroups. A further breakdown showed 15 percent of the fecal samples contained serogroups consistent with enterotoxigenic *E. coli.* These so-called ETEC *E. coli* are normally associated with travelers' diarrhea.

Serogroups consistent with enterohemorrahgic or EHEC *E. coli* were found in 7 percent of the fecal samples. These serogroups can be highly virulent, can cause bloody diarrhea, and can have a toxic effect on the kidneys.

Finally, 6 percent of the samples contained serogroups consistent with enteroinvasive or EIEC bacteria, which can be more invasive than the previous two types listed. EIEC bacteria can penetrate the colon and cause dysenterylike diarrhea with fever.

Identification of the above O-serogroups still does not prove that *E. coli* strains found in goose feces produce disease in humans. Only if the specific toxins that cause human disease are identified in these serogroups can researchers show the possibility of disease transmission from geese to humans. Accordingly, one of the objectives of the current 3-year Waterfowl Zoonotics Research Project is identification of the individual toxins in goose feces' *E. coli* serotypes. Another objective of the project is to develop an index that relates terrestrial fecal coliform counts (primarily in parks) to the risk factors such as those identified above. Public health officials already monitor water quality looking at fecal coliform counts. The general rule is that if such counts are high, there is a reasonable chance that some of the coliforms might be pathogenic to humans. A terrestrial index would provide a rational basis for Canada goose management decisions in the parks. To reach these objectives, NWRC has enlisted the cooperation of WS staff to collect fecal samples in California, Colorado, New Jersey, New York, Oregon, Washington, and Wisconsin for analysis. Each State is providing 100 samples from 2 sites every other month. So far, assays show low prevalence of *Salmonella* in Canada geese. Assays for *E. coli* were incomplete at the end of FY 2000. Testing also has uncovered other bacteria in feces such as *Citrobacter* spp., *Enterobacter cloacae, Panoea* spp., *Proteus* spp., and *Providencia* spp.

MAMMAL RESEARCH PROGRAM

Title: Reducing Wildlife Damage to Forest Resources

Goal: Develop feasible and effective methods for reducing wildlife damage to forest resources.

Effects of Supplemental Feeding on the Behavior and Nutritional Status of Black Bears—Bear foraging can be devastating to timber plantations in the Pacific Northwest. Bears emerging from hibernation before green plants, berries, and insects are available kill or severely damage commercial trees by stripping bark and consuming cambium. One nonlethal approach used by timber managers to alleviate this damage is to provide bears an alternative food. Although this supplemental feeding has been used for the past 15 years and has grown to include more than 850 feeding stations in Washington and Oregon, few data were available to identify actual efficacy or possible long-term consequences of the program. NWRC scientists have worked with a group of private, State, and Federal natural resource managers to develop and conduct a series of studies to provide a better understanding of the impacts of the supplemental feeding program.

First, the researchers examined the intensity of black bear damage found on timber stands located on the Olympic Peninsula of Washington and conducted an experiment to assess the efficacy of a supplemental feeding program to reduce future damage to these sites. The survey revealed an average damage of more than 20 percent in affected timber stands. Stands were subsequently paired according to damage intensity, and one stand within each pair was randomly selected to receive a supplemental feed treatment.

Initial data indicated that substantially less damage occurs on sites with feeders than on sites without feeders when measured 1 year after the feeding program was implemented.

Concurrent studies were conducted to determine the sex and ages of bears using feeding stations and assess the interactions of bears around the feeders and impacts of the program on bear home ranges. Numerous bears fed at the stations, including females with and without cubs, yearlings, and adult males. Bear feeding bouts at the stations were generally short, averaging less than 30 minutes. Bears generally fed alone, although sometimes two or three adult bears were observed at a feeder simultaneously.

There was little aggressive behavior observed around the feeders. When it did occur, there was no evidence that it significantly inhibited or delayed feeding. On the rare occasion a bear was driven from a feeder, it returned later that same day to feed, generally within an hour.

Bear home ranges that included feeding stations were the same size as home ranges of bears without feeding stations; however, there may be more overlap of territories at feeding sites. Also, during the spring, bears with feeders do not visit some parts of their territory as frequently as do those without feeders.

Another study was conducted to evaluate the impact of supplemental feeding on the nutritional status of bears. Bears were captured in areas where supplemental feed was provided and in control areas where no effort to reduce damage occurred. Captures occurred during two periods: early spring (April and May), before food plants were available, and early summer (June and July), after food abundance had increased. Body composition, mass, and diets were determined for all bears captured.

Mass gains for bears were 153 g/day in the feeder areas and 12 g/day in the nonfeeder areas. Fat gain for bears in the feeder areas was 42 g/day versus 4 g/day in the nonfeeder areas. However, since final age-specific body masses and fat content of bears did not differ between the two areas, short-term pellet feeding appears to have no lasting effect on bear condition or productivity.

The diet of bears in the nonfeeder areas was 91 percent vegetation and 9 percent animal matter. The diet of bears in the feeder areas was 58 percent pelletized feed, 38 percent vegetation, and 4 percent animal matter. Grasses and sedges comprised the majority of vegetation consumed in both areas. Cambium from Douglas-fir and western hemlock was more digestible (62 to 71 percent) than were grasses and forbs (12 to 52 percent).

The investigators speculated that smaller bears (adult females and subadult males and females) may do most of the timber damage because the time required for cambium harvesting may minimize the nutritional gain for larger adult males.

Assessing Secondary Hazards of Strychnine Baiting for Pocket Gopher Damage Control—Strychnine baiting (with bait enclosed in underground burrows) is commonly used to reduce pocket gopher populations prior to planting tree seedlings in the Pacific Northwest. Some nontarget rodent mortality may occur, and the fate of these individuals, as well as that of pocket gophers, presents a potential for nontarget mortality after baiting. NWRC scientists conducted a series of studies to assess whether pocket gophers which die from strychnine poisoning subsequently pose a risk to predators and scavengers.

The first study was conducted to document the fate of pocket gopher carcasses left above ground on an Oregon national forest at the time of year when strychnine baiting is normally conducted. The results indicated that wasps and ants were the insects predominately responsible for carcass degradation and that the rate of carcass disappearance was influenced by temperature and hence the number of insects and the species involved. During warm weather, carcasses disappeared within 72 hours, while carcasses placed

during cool, damp periods remained for over a week. A few carcasses were removed by unidentified birds and mammals.

Because the first study implicated insects as primary factors in the degradation of carcasses found on sites treated with strychnine bait, a second study was initiated to determine whether these insects pose a tertiary threat to insectivores. Many species of insects are unaffected by strychnine, with the compound passing unchanged through the digestive tract of beetles. Insects have been collected from a variety of strychnine-treated and untreated pocket gopher carcasses. Chemical assays will determine the amount of strychnine found within each insect species.

Two other studies determined the location of pocket gopher carcasses to assess whether they were likely to pose a secondary hazard to other wildlife species. In one, pocket gopher activity after strychnine baiting was examined in pens constructed to simulate pocket gopher-infested sites in national forests. Baiting procedures were used that simulated those used during operational baiting. A second trial looked at the impact of a heavy mat of straw on the soil surface. Pocket gophers spend more time on soil surfaces that have an increased density of ground cover. However, regardless of ground cover density, pocket gophers in both trials, died below ground. Animals were found either in nests or in burrows, thus posing no hazard to other species active above ground. Similarly, the belowground caches of bait found in five pocket gopher nests would be expected to present no hazards to animals using the ground surface.

Finally, the potential hazards of pocket gopher carcasses in underground burrow systems were examined using weasels. Weasels and a few other mustelid species move within pocket gopher burrows to prey on pocket gophers and could encounter carcasses. This potential exposure could suggest a greater risk of secondary hazards to weasels than to aboveground predators or scavengers. Subterranean and nocturnal animal activity is difficult or impossible to observe directly in field situations. Therefore, an extensive artificial burrow system was constructed from clear plastic pipe to assess weasel responses to pocket gophers that died after ingesting strychnine. Weasels did not respond differently to pocket gophers treated with strychnine than they did to untreated carcasses. Although weasels were observed to feed on dead pocket gophers and to cache pocket gopher carcasses in burrows, none of the weasels died after ingesting strychnine baited pocket gophers. There are at least two reasons for this: one, the concentration of strychnine in gophers is considerably below the lethal dosage unless a weasel eats substantial amounts, which none did; or two, the weasels failed to eat the gastrointestinal tract, which is where strychnine is most likely to reside in poisoned animals. Additional work is needed before either hypothesis can be confirmed. Caches of more than two pocket gophers have not been observed. Larger caches could pose a potential risk to badgers or other animals that discover and pillage weasel caches; however, the preliminary results from these studies suggest that using strychnine bait to reduce pocket gopher damage to seedlings presents little or no risk to weasels.

Title: Reducing Beaver Damage to Agricultural Resources

Goal: Develop feasible and effective methods for reducing beaver damage to agricultural resources.

Potential of Repellants To Reduce Beaver Damage to Trees—Beaver foraging along streams can damage tree plantings and impede the recovery of riparian zones by gnawing stems or clipping seedlings. NWRC scientists have been investigating whether repellants are feasible tools to reduce this damage. None of the commercial repellants tested prevented beaver from girdling mature trees; however, two repellants demonstrated some efficacy in protecting seedlings and foliage from beaver consumption.

Fewer seedlings treated with Big Game Repellent®—Powder or Plantskydd® were clipped than untreated seedlings or those seedlings treated with other repellants.

A textural repellant using 30-mm quartz sand in an alkyd paint base was developed by NWRC scientists and has shown favorable results when used operationally by WS specialists. NWRC scientists are continuing to investigate means to improve this possible tool and make it more widely available.

Use of Pond Levelers To Meet Landowner Objectives for Beaver Damage Management—NWRC scientists worked with WS specialists to identify factors that affect whether Clemson beaver pond levelers installed by WS met landowner objectives. The Clemson beaver pond leveler was developed as a tool to enable land managers to manipulate water flow past beaver dams. WS has used this technique extensively in the Southeast in assisting landowners in managing beaver damage. Forty-five landowners using levelers installed by WS were surveyed to determine if the units were

still operating and whether the installations were regarded as successful.

The landowners regarded 45 percent of the installations as successful in meeting management needs. Choice of original management objectives closely correlated with owner satisfaction. Devices installed to manage wetlands (primarily waterfowl habitat) were generally considered successful; devices installed to provide water relief from flowing streams were found to be less successful. Time elapsed since installation was not a factor; however, maintenance of the levelers was important. Of the still-operating levelers, 63 percent had received some form of postinstallation maintenance. Levelers placed in sites with high beaver activity frequently failed unless they were used in conjunction with population control measures. Physical attributes of the site or characteristics of the beaver dams were not closely correlated with success of the levelers.

Title: Selective Targeting of Adult Territorial Coyotes To Manage Sheep Depredation: Efficacy and Methods

Goal: Determine the efficacy of selective removal of adult territoral coyotes whose space overlaps sheep pastures as a strategy to reduce depredation losses and determine how to selectively target these coyotes.

Attracting Dominant Coyotes With Broadcast Calls—In ongoing research in northern California, NWRC scientists and cooperating scientists are determining the responses of alpha coyotes to broadcast calls. Calling-and-shooting has long been used as a method to reduce livestock predation by coyotes. If specific coyotes that kill livestock can be attracted selectively, this method could be used more efficiently to manage predation.

NWRC scientists believe that alpha coyotes are most likely to approach a call that imitates an intruder within their territory. In an earlier study, it was found that alpha coyotes with territories overlapping sheep pastures were responsible for most sheep predation. These adult, territorial coyotes were relatively more difficult to remove with traps, snares, and M–44s than were younger, less experienced animals.

To begin this research effort, a Geographic Information System (GIS)-based data-management system was developed to map the preserve. Coyotes were then captured and radio-collared to determine their social status and space-use patterns. Researchers then directed broadcasted calls at individuals known to be alphas, betas, or transients and recorded their responses (approached, withdrew, or ignored). The test site covered 27 km^2 and included all or part of 6 contiguous coyote territories in which there were about 25 collared coyotes. About 70 trials, beginning in March 2000, were conducted over 6 months for this purpose.

Nine different types of calls were examined, including coyote calls, prey distress calls, and a broadcast siren. Some of the calls were recordings of the animals themselves while others were recordings of coyote imitations by WS field personnel. Also, five different broadcast times of the day were examined. Movements of radio-collared coyotes were monitored for 1 hour after the call to determine responses.

The first 50 of about 200 planned trials for seasonal comparisons had been completed at the end of FY 2000. In 60 percent of the trials in which responses occurred, 113 responses by radio-collared coyotes were obtained. Of those, 18 responses were approaches and 7, retreats. Group howls were the most common response. Other responses included coyotes circling downwind before retreating and coyotes ignoring the broadcasted call. Alpha coyotes, alone and as pairs, approached broadcasted calls from as far as 2 km away. Betas approached as part of packs, but it was unclear whether betas ever approached alone. Packs of up to seven individuals approached. In some cases, pack members or alphas that had been separated joined en route to the broadcast site.

The field tests are continuing, and more detailed analyses are underway to examine the effects of call type and time of night on coyote responses.

Title: Reproductive Intervention Strategies for Managing Coyote Predation

Goal: Determine whether sheep losses to predation can be reduced by sterilizing coyotes on territories where sheep and other livestock are pastured. Develop and transfer information critical to the registration and/or practical application of sterilant technology.

Sterilization as a Method of Reducing Coyote Predation on Domestic Sheep— Coyote predation on domestic sheep has long been a problem for the sheep industry throughout the Western United States. The provisioning of pups seems to be an important motivational factor for coyote depredation on lambs during the spring months in the Intermountain West. NWRC scientists, working with a Utah State University graduate student, evaluated coyote sterilization as a method of reducing sheep losses to coyote predation on open range in northeastern Utah. Coyotes were captured, surgically sterilized by tubal ligation or vasectomy, released, and monitored over 3 years by radio telemetry. Small flocks of sheep (ewes and lambs) were moved periodically through all coyote territories, and sheep kills were monitored through the summer grazing seasons.

Sterilization, while not eliminating killing behavior, did significantly reduce coyote predation rates on sheep. While 4 of 9 sterile coyote packs killed a single lamb each, 7 of 14 reproductively intact packs killed between 1 and 13 lambs. Among packs that killed sheep, intact packs with pups killed six times more sheep than sterile packs. Packs with sterile coyotes maintained pair bonds and territory fidelity similarly to reproductive packs with no difference in territory size. A sterile coyote pair, which is killing fewer lambs and excluding other possible sheep-killing coyotes, could provide an effective management tool, provided practical, economic methods of producing selective sterility can be found.

Reproductive Intervention Strategies for Managing Coyote Predation— Without young to feed, adult coyotes are much less likely to kill livestock, and possibly big game (e.g., mule deer and pronghorn). NWRC scientists are studying chemical and immunologic methods of controlling coyote reproduction and are developing methods for the early detection of pregnancy in coyotes so that this research can proceed more rapidly.

Past research has shown that porcine zona pellucida (PZP) injections can sterilize coyotes, and efforts are now focused on identifying which fragments of the PZP molecule are critical for producing this effect. Knowing that information will allow critical fractions to be synthesized with concomitant increases in potency and a continuation of work on oral delivery.

The most promising material examined to date is cabergoline, a substance commercially available in Europe for veterinary use with dogs. Studies conducted in 1998 with individually kenneled animals suggested that 25µg/kg of cabergoline could prevent successful pregnancies in most coyotes that ingested it. In 1999, similar results with dosage regimens of 25, 30, and 50µg/kg administered daily for 7 days to coyotes paired in outdoor pens could not be replicated. A possible explanation is that cabergoline effectiveness can be compromised by differences in social setting or perhaps by environmental variables not present when animals are caged separately. These possibilities are intriguing and practically important. Cabergoline has been tested with positive results with individually housed wolves, coyotes, and red foxes. While only coyotes have now been tested in a social setting, it is clear that significantly different results may occur.

Determination of pregnancy in canine species, including coyotes, prior to day 30 of gestation is difficult. ReproCHEK™, a qualitative test for early pregnancy determination in domestic dogs, was evaluated in coyotes. The test detects relaxin, a circulating hormone that increases as a result of fertilized egg implantation. Coyotes were paired in outdoor pens and observed for breeding behavior. To detect pregnancy status, females were physically examined 30 days after the first observed mating. During this period, weekly blood samples were also obtained from females and analyzed for relaxin using the ReproCHECK test. Results suggested that the ReproCHEK test could accurately predict the pregnancy status of coyotes even as early as 21 to 24 days of gestation. This test will be a valuable tool for increasing the efficiency of examining candidate reproductive control agents.

Interactions Between Timber Wolves and Agriculture in Northwestern Minnesota—The timber wolf population in Minnesota numbers an estimated 2,500 animals. Once believed to be a species requiring wilderness, wolves now occupy the agricultural region of northwestern Minnesota. Farmers' concerns about wolf recovery in these areas prompted an investigation into the potential risk that wolves pose to livestock.

From June 1997 to November 1999, NWRC scientists worked with a Utah State University graduate student to capture, radio-collar, and track 17 wolves in and around a national wildlife refuge. The refuge is surrounded by agricultural lands, with 33 livestock pastures within 3 miles of the refuge border. The Eastern Timber Wolf Recovery Team had originally suggested that this area should be kept wolf free because of the preponderance of agricultural land; however, wolves have been resident on the refuge since the early 1980s.

Analyses of data from 24-hour radiotelemetry tracking sessions demonstrated that the wolves residing on the refuge traveled mostly at night and used the agricultural lands during all seasons. Night trips, in which the wolves visited several pastures containing livestock and then returned to the refuge, were documented. Despite their close proximity to livestock, the wolves consumed mostly native prey: white-tailed deer, moose, and muskrats; however, the potential risk to livestock remains an important concern for landowners.

Title: Alternative Capture Systems and Aversive Stimulus Applications for Managing Predation

Goal: Identify, develop, and evaluate advanced capture systems and aversive stimuli applications for predation management emphasizing animal behavior and engineering approaches.

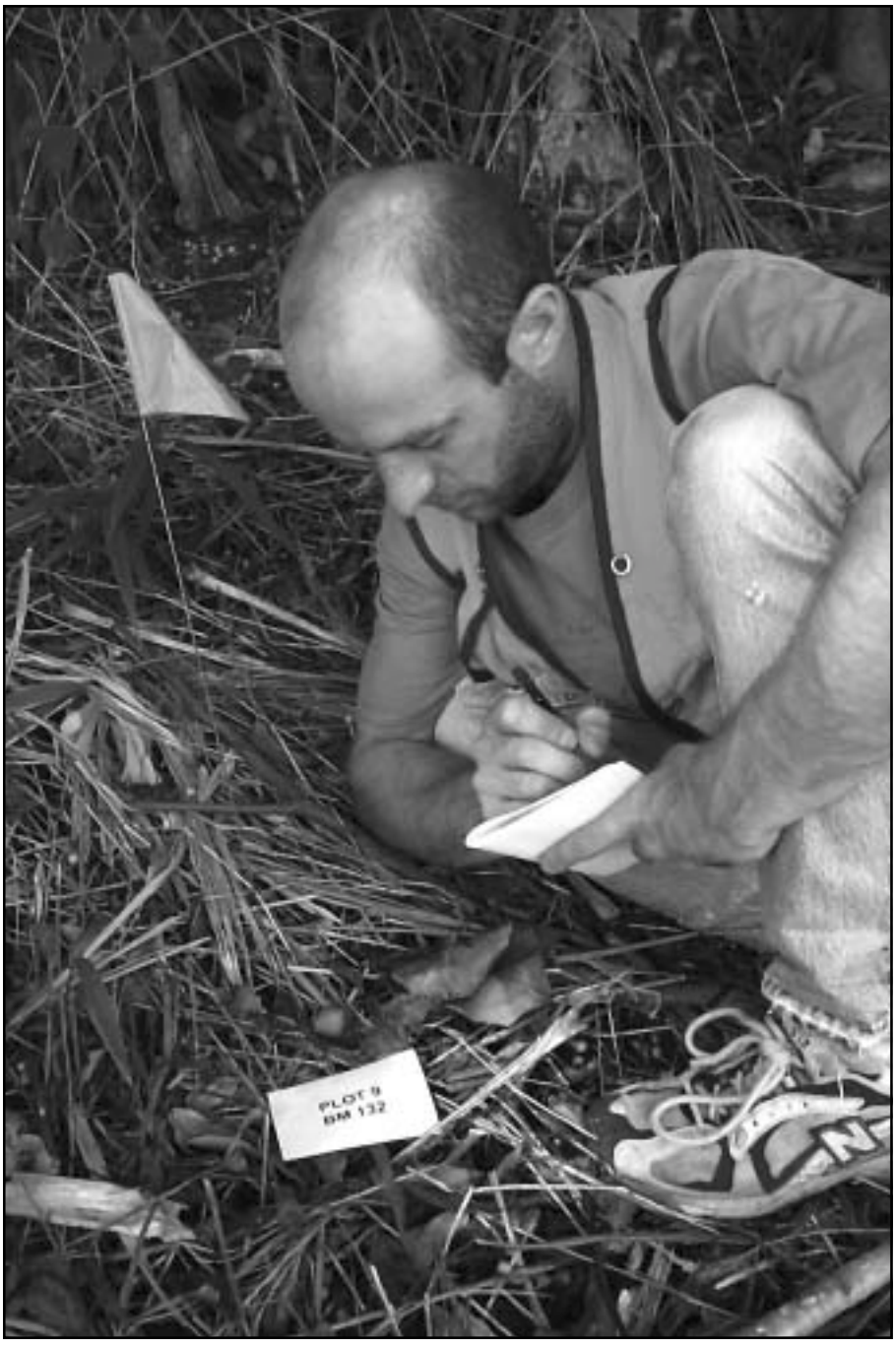
Using Electronic Technology To Resolve Conflicts Between Humans and Predators—NWRC scientists are cooperating with several organizations to test electronic devices originally developed as prototypes by NWRC scientists working with the U.S. Fish and Wildlife Service (FWS) and Defenders of Wildlife. A predator-activated Electronic Guard frightening device was developed and placed in an area where wolf predation on calves had occurred. Based on examination of wolf tracks and radio telemetry locations, this initial field study indicated that the device, activated by radio collars on approaching wolves, successfully repelled previously depredating wolves from a calving area. Because of the potential usefulness of this device, two prototype radio-collar activated predator frightening systems have been produced and are currently being used by WS specialists managing wolf conflicts. Current efforts are aimed at lowering cost and improving ease of use of the device by incorporating wireless and miniaturized components.

NWRC scientists and WS operations personnel worked with the Turner Endangered Species Fund, the University of Montana, and Defenders of Wildlife, to determine the effectiveness of electronic collars for conditioning wolves not to attack livestock. Based upon previous work indicating the effectiveness of the aversive stimuli produced by the collars for conditioning coyotes, NWRC personnel are testing the concept using captive wolves in Bozeman, MT. Similar studies in Wyoming are underway to develop prototype systems for automatically attaching radio telemetry collars to large predators. Such systems would allow radio-marking of animals near predation sites without requiring capture and handling. The concept could dramatically increase the applicability of radio telemetry and aversive-collar devices for large predators.

Title: Holistic Management of Rodents and Other Introduced Vertebrate Pest Species in Hawaii

Goal: Develop safer and more effective methods for reducing rat damage to Hawaiian agricultural crops.

Simulation of Broadcast Rodenticide Application in Hawaiian Native Forests—Introduced rodents have had and continue to have significant negative impacts on agriculture, human health, and native ecosystems in Hawaii. Rodent control is considered a high priority for implementation of many of the species and ecosystem restoration plans in Hawaii. Aerially broadcast rodenticides have successfully been used to control introduced rodents on islands in New Zealand. This apparent success encouraged wildlife biologists and State agencies in Hawaii to seek regulatory approval for the use of similar techniques in Hawaii. In 1995, a State registration for the use of anticoagulant bait blocks in bait stations to reduce rat depredation in Hawaiian native ecosystems was approved. Several Federal, State, and nongovernmental wildlife management agencies and private industry groups with interests in endangered species recovery are currently collaborating to obtain a similar registration for use of aerially broadcast rodenticides in conservation areas.



An essential first research step was to determine an optimal broadcast application rate bait to assure that a high proportion of rats in natural forest areas find and consume pelletized bait. To this end, a placebo baiting study was completed by NWRC scientists, in cooperation with the State of Hawaii and FWS to obtain information on an application rate that would result in maximum exposure of bait to the rats while minimizing bait usage. The study consisted of three replicates of controlled field trials on 1-ha forest plots using a pelletized placebo bait (Ramik® Green

formulated without diphacinone) treated with a biological marker (tetracycline hydrochloride) and broadcast at three application rates (11.25, 22.5, and 33.75 kg/ha).

All Polynesian rats captured in all application rate plots had eaten the broadcast bait. The percentages of roof rats that had eaten the bait were 71 percent, 94 percent, and 96 percent in the low, medium, and high application rates, respectively. Based on these results, the optimal application rate seems to be 22.5 kg/ha. Bait degradation and invertebrate activity on and around broadcast baits were also determined.

Techniques To Control Introduced Tree Frogs in Hawaii—The Coqui frog and the greenhouse frog, two species of neotropical tree frogs, have been introduced into the State of Hawaii through horticultural trade—perhaps to the island of Hawaii—up to 13 years ago. Since 1997, frog infestations within the State have rapidly spread, both accidentally and intentionally, and frog abundance within colonies has grown rapidly. These frogs have become increasingly widespread and abundant on the islands of Maui and Hawaii. Currently, there are known colonies of these frogs at more than 40 locations on the island of Hawaii, more than 35 on Maui, 3 on Oahu, and 1 on Kauai. Although the frog populations were originally restricted to horticultural sites such as plant nurseries, they are now found in residential areas and on resort and hotel grounds and public lands. Individual frogs or frog colonies have been verified at sites ranging from sea level to above 3,500 feet. Within their native range, where population growth may be constrained by predation and other natural checks, these frogs may reach densities of 20,000/ha and consume an estimated 140,000 prey items per ha per night. Given the current population irruptions of these frogs in Hawaii, similar densities could be reached or exceeded if frogs become established in native ecosystems.

From an economic standpoint, the presence of these frogs in nurseries in Hawaii is a quarantine issue because frogs accidentally exported in infested plant material may be a potential vector for plant pathogens or nematodes in certified nurseries. Coqui frogs have loud, high-pitched calls, and when population densities become high, the sounds of their calls may reach deafening levels. There are a growing number of complaints by residents and hotels on the islands of Hawaii and Maui about the loud calls of these frogs during the night.

Because Hawaii has no native frogs, there is growing concern that high densities of these introduced frogs could negatively affect native birds and invertebrates through competition and predation. Should frog populations become established in natural areas, they would consume a large invertebrate biomass and could play a direct role in the decline of native invertebrate species through predation. The frogs would also compete with native bird species for food. In addition, high densities of frogs would increase the prey base for invasive predators such as rats, mongooses, and cats.

The full ecological impact of these frog introductions in Hawaii is yet to be determined.

Adding to the problem for agricultural and wildlife managers is the fact that no known control techniques are available to contain the expansion of this frog invasion. NWRC scientists continue to work with State agencies to develop traps and chemical control techniques for introduced tree frogs. Research indicates that the application of commercially available insecticides registered for horticultural use have little or no effect on either species of introduced frog. However, initial laboratory chemical screening tests showed that caffeine might be developed as an effective treatment for localized control of these frogs. NWRC scientists and their colleagues are continuing to examine the potential for developing a caffeine formulation or other control techniques to help Hawaii State agencies and the horticultural industry halt the spread and minimize the impacts of these invasive species.

PRODUCT DEVELOPMENT RESEARCH PROGRAMS

Title: Integrated Pest Management Strategies for Rodent Damage to Agriculture

Goal: Develop, test, and evaluate innovative and integrated methods and models to predict, monitor, and reduce rodent damage to agricultural crops and property.

Controlling Rodents at Airports by Using Zinc Phosphide—The grassy areas at airports are often home to many rodent species. These rodents, in turn, are food items of choice for many species of raptors. Airport managers want to reduce the use of runway areas by raptors and other large birds because of the airplane strike hazard.

NWRC scientists monitored rodent populations at a Kansas airport before and after the application of a 2-percent zinc phosphide–rolled-oat bait (ZP bait). The data were required by EPA, which was reviewing reregistration applications for ZP baits.

Meadow mice and deer mice numbers were reduced by 85 percent or more, based on snap-trapping and live-trapping grid results. Observations of raptors have declined at the airport since initiation of the rodent baiting program. It appears that airport managers can maintain low numbers of rodents by the combined use of habitat management, good sanitation practices, and the judicious use of rodenticides.

Investigations of Methods To Reduce Damage by Voles—Voles, small burrowing rodents, range over much of North America. Populations cycle and achieve peak densities every 3 to 5 years, at which time voles do severe damage to various resources. Various methods are used to reduce vole damage, but there is still a need for new, cost-effective, and environmentally benign approaches.

NWRC scientists investigated numerous candidate repellants and barriers with indoor vole colonies in soil-filled tanks. Several compounds (blood meal, capsaicin, castor oil, coyote urine, quebracho, and thiram) showed promise as repellants but only at high concentrations. Many other compounds were completely ineffective.

Voles breached short physical barriers, either by climbing or burrowing. Taller barriers were less often breached by voles. Adding a repellant, coyote urine, inside the barrier increased barrier effectiveness. A tactile barrier (sand in acrylic paint) did not lessen the gnawing of hybrid poplar sticks.

While some of these approaches appeared promising, field testing will be needed to determine the cost, effectiveness, and duration of protection under more natural conditions. Vole management should be approached within the context of an integrated pest management strategy.

Capsaicin's Persistence in Soil— Chemical irritants, particularly capsaicin-based products, have gained wide use as animal repellants. In 1998, NWRC scientists showed that soil containing at least 1.5 percent gravimetric capsicum oleoresin decreased the soil-contact time of pocket gophers about 50 percent relative to control animals on clean soil. Of course, the persistence of capsaicin in soil is crucial to the repellant's efficacy and cost effectiveness. Thus, in a recent test, the persistence of capsicum–oleoresin in soil was evaluated. Five capsaicin–soil mixtures (0, 0.7, 1.5, 3, and 6 percent capsaicin) were prepared and exposed outdoors for 28 days. The soils were sprinkled daily for 14 days with a 0.65 cm of water, then kept dry for another 14 days.

The 8.25 cm of simulated rainfall caused about 40 to 50 percent of the capsaicin to be washed away, but in the absence of water, the irritant persisted unaffected. This finding gives some indication of the length of time that "hot-chile-pepper-type" animal repellants will remain in

the ground and suggests that the material may be useful as a burrowing rodent repellant, especially in dry regions.

Benefit:Cost Decisionmaking in Wildlife Damage—Computer spreadsheets make projections of benefit:cost ratios and net crop savings readily available to most farmers, ranchers, and wildlife damage professionals. Still, such calculations are rarely mentioned or used in wildlife damage management decisionmaking. Spreadsheet analysis of variables including field size, crop loss, mitigation effectiveness, and application cost affords insight into the economics of implementing wildlife damage management activities.

In 2000, NWRC scientists developed spreadsheets to compute economic analyses for the use of the rodenticide zinc phosphide to reduce vole populations in alfalfa. Market data for 1998 showed that U.S. alfalfa yields averaged 7.77 tons/ha and that customers paid $100.33/thousand tons for the commodity. Plain (prebaiting) and zinc phosphide baits cost about $0.42/kg and $2.73/kg, respectively. The baits are registered for application at 11.2 kg/ha.

Using these data, NWRC investigators performed spreadsheet analyses of net savings and benefit:cost ratios for varied size fields (ha), crop damage (percent), bait efficacy (percent), and applicator costs (dollars/ha). Results showed that greater net savings and benefit:cost ratios were related to larger field sizes, increased crop damage, and increased bait effectiveness variables but smaller bait application fees. Benefit:cost ratios showed that at least 5 to 10 percent damage by voles was required to produce sufficient returns to justify rodenticide investments. Damage at the 10- to 20-percent level was needed to yield double or triple returns.

NWRC scientists are adapting this approach to assess other wildlife damage management tools and situations, including methyl anthranilate use to deter geese from parks and golfcourse fairways, capsaicin to protect cables, and overhead monofilament lines to deter bird visitations to aquaculture ponds.

Bait Attractant, Prebaiting, and Zinc Phosphide Rodenticide Interactions— Rodenticide baits used in agricultural fields are frequently ineffective for reducing local rodent populations due to several factors that conflict with wild rodent feeding behaviors. Few studies have assessed the integration of odor attractants or repellants with baits to improve efficacy. Carbon disulfide at 10 p/m, has been shown to increase untreated bait intakes of wild Norway rats. NWRC scientists evaluated this material during 3-day prebaiting and 1-day baiting intervals with albino rats in laboratory cage tests using zinc phosphide.

Carbon disulfide was introduced as an odor material for half the exposed animals, and distilled water served as a control odor for the unexposed animals. Test groups were established based on gender and prebaiting versus no prebaiting.

Results showed a 220-percent increase in bait intake attributed to prebaiting and a 29-percent increase due to the presence of the carbon-disulfide attractant. These effects were mainly due to increased consumption by female rats. If this increase in consumption by females is substantiated under field conditions, baiting with a combination of zinc phosphide and carbon disulfide could cause a decline in the proportion of females in the population, which would in turn, suppress rapid recovery of local populations in agricultural areas.

Monitoring Feral Swine Populations— Feral swine have established free-ranging populations in many States, where they cause considerable damage to crops and natural resources and pose a disease hazard to humans and livestock. An NWRC scientist tested a passive tracking plot index to monitor feral swine at a State park in Florida. The method had been developed and used successfully to monitor changes in coyote populations in Texas before and after population control. In Florida, the method was not only used to monitor feral swine populations before and after swine control but also was modified to provide an index of the pervasiveness of feral swine in the area.

The tracking index declined by about 60 percent after 1 month of control while an index of swine damage declined by 89 percent. The pervasiveness index suggested that the remaining feral swine were highly localized. These monitoring methods are being used by State park personnel in Florida to monitor the feral swine population and to help assess the need for future control operations.

Title: Induced Infertility: A Wildlife Management Tool

Goal: Develop and test economical and effective agents to control fertility in populations of pest mammals and birds.

Canada Goose Population Control with Nicarbazin—NWRC is conducting research on an infertility agent in collaboration with a nicarbazin (NCZ) manufacturer who has an FDA-approved use of NCZ in broiler chickens for control of coccidiosis. Large-scale broiler chicken production is not possible without effective control of this parasite. NCZ added to the feed is provided to broilers continuously for 38 days of their 42-day lifespan to control coccidiosis and increase weight gain.

One of NCZ's side effects is that if fed to breeder or layer chickens, their eggs, although fertilized, often do not hatch. NCZ causes yolk-mottling due to fluid transfer from the albumin (white) into the yolk via increased yolk membrane permeability. Severe yolk membrane breakdown causes the yolk and albumin to blend together, destroying the conditions necessary for viable development of the embryo. Other than reduction in egg hatchability, NCZ has no health effects on poultry. When NCZ is withdrawn from the diet, egg production resumes within a few days. NCZ has no known effects on mammals. NWRC is interested in development of NCZ as an oral control agent to reduce goose fertility.

NWRC has begun to study the use of this compound to control overabundant avian species. In a pilot study conducted in 1998, NWRC tested the effect of NCZ on Japanese quail reproduction in a laboratory setting. The study demonstrated that NCZ was effective in limiting the hatchability of eggs in species other than chickens.

Based on that study, NWRC began testing the compound as an oral reproductive control agent for the Canada goose. In a 1999 study, researchers found that Canada geese absorbed NCZ into the blood serum, although at a lower rate than found in chickens. Several other laboratory and field studies conducted in the Spring of 1999 also indicated that NCZ is a promising candidate for use in lowering reproduction rates in Canada geese.

Development of Contraceptives for Rodents—The use of diazocosterol (Diazacon®) as a potential wildlife contraceptive is currently being investigated in a prairie dog field trial and a rat laboratory study. Diazocosterol (20,25 diazacholesterol HCl) is a cholesterol inhibitor that is capable of inhibiting reproductive hormone synthesis for a period of several months. It therefore has the potential to be a useful tool for population control in a variety of animals. Historically, it has been used with variable success in field settings to reduce populations of urban pigeons, a bird species that breeds throughout the year. Theoretically, success rates with this compound should be higher in wildlife populations in which breeding is seasonal. In this initial field study with prairie dogs, two groups each of untreated and treated animals were tested. The diazocosterol was presented to prairie dogs in a bait consisting of 0.25 percent diazocosterol on rolled oats coated with molasses.

The study analyzed cholesterol levels in blood serum, relative numbers of lactating females, and relative numbers of pups born to treated versus control females. Results were not as good as anticipated. Sample sizes of females trapped to check for lactation were low, especially in the treated groups. Both treated and control groups had lactating females. Trapping over a 3-day period showed 4 of 5 treated and 22 of 22 control females were lactating. An index obtained by visual observations of prairie dog numbers showed that, in treated groups, the proportion of juveniles to adults was 16:24 (0.7); untreated groups had 35 juveniles to every 21 adults (2.7). Treated groups had 59 percent fewer pups.

Levels of blood serum cholesterol over the course of the experiment have not yet been analyzed. Hopefully, blood analysis will help establish what proportion of the population ingested a sufficient amount of bait. This will allow researchers to determine if the bait was avoided by prairie dogs or whether the diazocosterol was only marginally effective in preventing pregnancy.

A laboratory study using the same diazocosterol bait is under way in wild Norway rats. Individually caged rats received bait in addition to their regular food. All bait was ingested by the rats by the end of the baiting period, and 71 percent of control and 50 percent of diazocosterol-treated female rats gave birth. Litters in both groups averaged eight pups. As the same bait was used in the rat and the prairie dog studies, limited success may be due either to a failure of rodents to adequately respond to the diazocosterol or to a failure of the bait delivery system. (The bait contained a number of fine particles that were not ingested but may have contained much of the diazocosterol.) Analysis of cholesterol blood levels and analysis of the bait should determine the true cause of diazocosterol's failure.

Title: Development of Chemistry-Based Tools for Wildlife Damage Management

Goal: Adapt and apply chemistry techniques to contribute to understanding chemical and biochemical aspects of wildlife damage to develop solutions for wildlife damage management.

Development and Testing of New Coyote Attractants—Coyote management requires species-selective attractants for the efficient delivery of drugs, reproductive vaccines, and toxicants and for the effective operation of traps and snares. Attractants must not only draw animals to devices but also elicit specific behaviors necessary for the proper operation of the device. Currently available attractants are typically complex and difficult to replicate from batch to batch.

NWRC research sought to identify the volatile components in commercial attractants for the purposes of preparing simple synthetic alternatives. To achieve this, commercially available coyote attractants were analyzed by purge and trap headspace analysis. All identified compounds were grouped according to chemical functionality, and one compound from each functional group was chosen to represent the group. Using only 17 representative compounds, 7 unique synthetic attractants were formulated.

These new attractants were tested by bioassay with captive coyotes. The behavioral responses elicited by the seven new attractants were compared to a currently available synthetic attractant (fatty acid scent) and a control. Results suggest that some of the synthetic attractants may have excellent utility in a variety of lures. For example, one attractant elicited significantly longer periods of digging than the other attractants or the control. That compound may represent a promising new attractant for trap lures. Another attractant elicited significantly longer pulling bouts than the control, suggesting that it may be useful for lures associated with oral delivery devices. Several attractants produced longer bouts of defecation than the control or fatty acid scent. In addition to being a desirable behavior in the context of capture devices, attractants that elicit defecation may be useful in ecological studies requiring scat deposition along transects as an indicator of coyote abundance.

Development of Analytical Methodologies To Determine the Safety and Efficacy of Chemicals for Wildlife Management—Rangeland rodents such as Belding's ground squirrels can cause measurable damage to rangeland grasses and water irrigation systems and pose a health risk to people. NWRC personnel working with a California State agency have completed a multiyear field and laboratory study to determine the safety of using chlorophacinone and diphacinone rodenticide baits to control pest ground squirrel populations. These rodenticide baits are typically applied by mechanical spreaders attached to all-terrain vehicles. The rodenticides were applied to rangeland plots during a field study in California. To determine if range grasses that are grazed upon by livestock may become contaminated by rodenticide application, NWRC's chemists developed methods to determine chlorophacinone and diphacinone residues in range grasses. Using these methods, the investigators analyzed field samples ranging from dry grasses to new growth collected in control and treated test plots for chlorophacinone and diphacinone residues. The study results indicate that these rodenticides can be safely used to control ground squirrel populations in rangeland grasses. No significant chlorophacinone or diphacinone residues were detected in any of the grass samples.

NWRC chemistry personnel are collaborating with other Center scientists in methods development research. Chemists developed analytical methods to quantify the amount of anthraquinone in spray formulations, as well as levels in lettuce, rice seed, ripening rice, and water. These methods will allow scientists to determine how much anthraquinone is needed to reduce bird damage effectively. Scientists will also be able to predict potential anthraquinone residues when crops are harvested.

Chemists developed methods to quantify absorption and excretion of nicarbazin and diazacholesterol in birds, mammals, and snakes used as test subjects for determination of proper dose levels and potential nontarget effects of the compounds.

Additionally, chemists developed procedures to analyze the amount of organochlorine pesticides in wildlife plasma, whole blood, and muscle tissue. These measurements are used to monitor wildlife contamination and cleanup efforts at a Colorado national wildlife refuge.

NWRC chemists developed new methods to determine metabolism and fate of a radiolabeled avicide, C-3-chloro-p-toluidine (CPTH) in susceptible and resistant bird species. The methods will permit WS to quantify the total toxic residues associated with use of CPTH and estimate potential nontarget hazards.

Secondary Hazards Associated With Use of DRC–1339—NWRC chemists synthesized a deuterated form of CPTH (DRC–1339) that was subsequently incorporated into a newly developed gas chromatography/mass spectrometry solid phase extraction method for quantifying CPTH residues in birds. This new approach significantly improves precision and accuracy in quantifying CPTH residues in birds. Using the extraction method, NWRC scientists were able to quantify CPTH residues in birds that had consumed a wide range of CPTH doses. These residue data permitted accurately determining potential secondary hazards to wildlife predators and scavengers that might consume carcasses containing CPTH. This approach will help to assure safe use of CPTH and to improve forensic abilities to determine CPTH poisoning in birds—information critical to confirming or refuting adverse incidence claims that could affect the registration status of CPTH. This new technique will help to assure the continued availability of CPTH, which is a significant benefit to WS operations and grower groups.

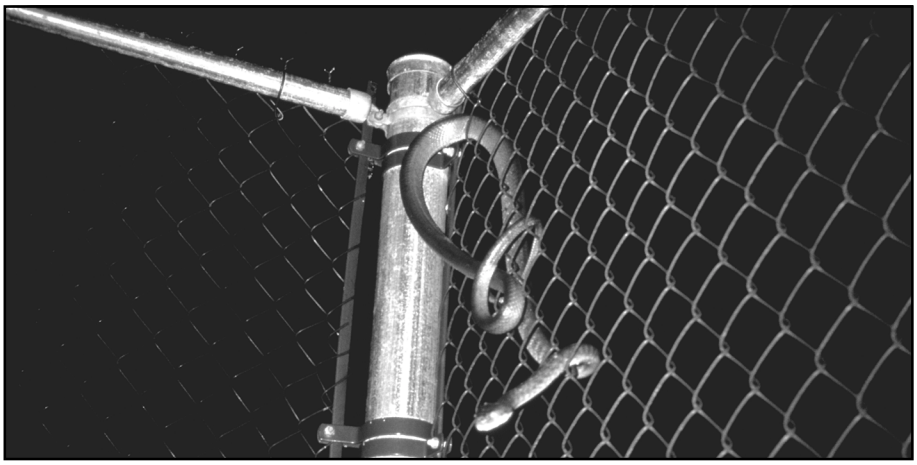
Analysis of Chemical Constituents Associated With Bear Damage to Timber—NWRC chemists in Fort Collins have developed and are applying methodology to separate and quantify terpenes and sugars related to determining the chemical nature of the forces that drive bear damage to timber, and are assessing the impact of silvicultural practices on these chemical constituents. They further are recommending practices to diminish the likelihood of damage and are building a significant body of knowledge and wildlife damage-management recommendations for the timber industry. This interaction is of great benefit to local timber industry groups. The approaches developed to complete this research can be applied to other herbivore wildlife damage situations, such as deer damage to agriculture.

Analysis of Potential Secondary Hazards Associated With an Anticoagulant Rodenticide—NWRC chemists developed a surrogate-corrected solid phase extraction residue method which permitted NWRC to quantify the rodenticide difethialone in magpies, ferrets, rats, and rat food. The data generated by these methods permitted NWRC to complete secondary hazard evaluations required for the registration of this new rodenticide.

Title: Field Evaluation of Chemical Methods for Brown Tree Snake Management

Goal: Develop techniques to help control brown tree snakes on Guam and prevent their dispersal from that island.

Background—FY 2000 was the second year of a 4-year project entitled “Field Evaluation of Chemical Methods for Brown Tree Snake (BTS) Management.” This is a follow-on activity to field test previously developed BTS methods identified in the "Development of Chemical Methods for Brown Tree Snake Management" project that was funded under the Department of Defense (DoD) Legacy Program from 1995 through 1998. The goal of that project was to identify chemical control methods (toxicants, attractants, repellants, and fumigants) that could be used in an integrated



program to control the BTS on and prevent its dispersal from Guam and reduce or help control snake populations in other island situations. The goals of the current project are to field-test these methods for efficacy and make them available for use by WS, its military and civilian cooperators, natural resource managers, military personnel, and others.

Oral Toxicant Research—

Reinvasion of Brown Tree Snakes After Control—In July 1999, a field study on Guam of 80-mg acetaminophen tablets in dead neonatal mice (DNM) to control BTSs showed that this toxicant and a PVC tube delivery system was highly effective. In February 2000, field crews censused the same plots for snakes 6 months after the original 1999 toxicant treatment to determine the extent of snake reinvasion. In 1999, the pretreatment bait take on treated plots was 84 percent and 80 percent; poisoning subsequently reduced snake densities to essentially zero. In 2000, snake densities had returned to the levels seen in 1999. These overall 6-month postcontrol results indicate that snakes return rapidly to treated plots from surrounding forests. The management implications of using toxic baits to control snakes clearly need to address methods to halt rapid reinvasion.

Comparison of Efficacy and Economics of Large-Scale Use of Toxicants v. Traps—NWRC biologists completed a study of the cost:benefits and comparative efficacy of trapping versus poisoning of the BTS as control methods on 6-ha forest plots. The economic analyses are ongoing, but the following is a summary of the efficacy of the two methods.

During a pretest period, estimates of snake populations on all plots, as determined by mark–recapture using Passive Integrated Transponder (PIT) tags, were similar. Snakes on the plots were removed either by trapping using WS standard traps or by poisoning using acetaminophen-treated DNM. The estimated rate of population decline was similar for the two methods of control. Following control, population estimates on both previously treated plots were derived using a mark–recapture method where trapping of PIT tagged snakes was monitored. These posttest trap results suggested that the posttreatment populations were similar for the two control methods.

After the posttreatment trapping, bait tubes were placed on all plots. Bait-take on the poisoned treatment plots was similar to that observed at the end of the treatment period. Bait-take on the trapped plots was 80 to 90 percent, levels normally seen during a pretreatment period. These data suggest that there is a population of snakes that get readily trapped but an additional population that is not caught by traps. In contrast, poisoned baits presented in open PVC tubes having both ends open appear to target both populations.

Snake Size and Trapability—One important issue that has affected both trapping and toxicant delivery success is a concern that small snakes are not being captured or killed in operational control. NWRC researchers assessed trapability by snake size by exposing captive snakes of various sizes to standard BTS traps containing a live mouse lure. Fifty-one snakes were exposed to traps overnight and then checked to determine which size snakes entered traps.

The results show a clear trend, with snakes > 1,000 mm snout–to–vent length (SVL) found in traps 91 percent of the time, snakes between 750 and 1,000 mm found in traps 75 percent of the time, and small snakes (SVL < 750 mm) found in traps 33 percent of the time. The investigators hypothesize that the trap design does not prevent small snakes from entering but that differences in snake behavior may affect their probability of encountering a trap. In captivity, it was observed that larger snakes were more active in the cages than the smaller snakes, which were usually inactive. Future research should identify if small snakes are generally less active “sit and wait” predators, which would lead to decreased likelihood of their encountering a trap in the lab or field.

Additional research related to oral toxicant development showed that (1) the acetaminophen concentration in baits exposed to environmental conditions over 4 days did not change; (2) 40-mg tablets are as effective as 80-mg tablets on all size classes of snakes, meaning the application rate can be reduced; (3) snakes taking toxicant baits die on the surface an average of 35 m from the bait station; and (4) fish crows, tested as a surrogate species for the endangered Marianna crow, while sometimes able to take a bait from the PVC tubes, will remove the acetaminophen tablet before eating the bait and will not die from an 80-mg injested exposure.

Postmortem Residues of Acetaminophen in the BTS—APHIS has an EPA Emergency Use Registration for applying 80-mg tablets of acetaminophen in DNM to conduct experiments on the BTS. Scientists who want to obtain a Section 3 registration must collect data in a number of areas. One concern about the use of toxicants is residues remaining in the target animal after death—residues that could present hazards to nontarget species. While DNM baits containing 80 mg of acetaminophen kill BTSs under field conditions, the environmental fate of acetaminophen residues in dead snakes is not known. To address this issue, NWRC researchers determined the residues of acetaminophen in BTSs killed by consuming dead mouse baits treated with 80 mg acetaminophen under laboratory conditions on Guam.

Five test groups of snakes, each containing three control and six treated snakes, were evaluated. Control snakes were fed an untreated bait and euthanized. The other groups of snakes were exposed to field ambient temperature and relative humidity conditions for 1, 2, 3, or 4 days.

Assays of acetaminophen residues in snakes are being conducted by NWRC chemists in Fort Collins. This residue data will be used for assessing potential secondary hazards of this baiting and its delivery system to potential scavengers and for estimating potential residues of acetaminophen in soil and water. Residue data from this study will be submitted to EPA to support the proposed Section 3 registration of acetaminophen as an oral toxicant for BTS.

Development of BTS Repellants—

Evaluation of Natural Product Compounds and Spray Machine Delivery Systems as BTS Repellants—Several naturally occuring compounds have been identified as repellent to BTS. These include cinnemaldehyde (oil of cinnamon), anise (oil of licorice), menthol (mint or peppermint), and cineole (eucalyptus oil). During 2000, a patent disclosure was filed for these and other compounds as repellants to the BTS. In addition, three delivery systems were evaluated for their ability to drive snakes from hiding spaces. When delivered as a vapor, cineole and cinnamaldehyde were effective 90 percent of the time in driving a snake from its hiding space in simulated cargo. Work remains to be done in the design of a portable delivery system. Prototype delivery systems will be evaluated in 2001.

Exploratory Reproductive Inhibition of the BTS—In 2000, NWRC completed its second year of exploratory reproductive inhibition research for the BTS. During 2000, NWRC successfully established a breeding colony of African house snakes that has proven to be an excellent test system for evaluating potential reproductive inhibitors. Female African house snakes in the NWRC colony have reproduced continuously throughout the year with each female producing a clutch of eggs at approximately 60-day intervals. This system, therefore, permits greatly accelerated testing of reproductive inhibition methods compared to that of any other known snake species.

Using this species, NWRC has completed an evaluation of the reproductive inhibitor NCZ, a registered coccidiostat that inhibits reproduction in chickens. However, although NCZ was absorbed well as judged by blood levels, it was not sequestered in the eggs at high enough levels to inhibit reproduction and egg hatchability.

Because the dose level used in this study was extremely high (10X the effective level in avian species) as was the frequency of dosing (up to six doses per individual), NWRC will not pursue further studies with this agent but will initiate work with another reproductive inhibitor, diazocosterol, a cholesterol mimic that disrupts synthesis of the reproductive hormones. A breeding colony of BTSs was also established at the NWRC, although with considerable delay. These delays have been overcome, and NWRC will attempt to begin breeding these animals by early October 2000.

PROGRAM SUPPORT

APHIS Registration and Reregistration Status

NWRC's Registration Unit is responsible for coordinating the development of data required by EPA and FDA to maintain the registration of current APHIS vertebrate control products or develop future product registrations. Additionally, the Registration Unit provides technical assistance and information to personnel located at WS State offices and to other individuals and groups.

Registration and Reregistration Status of APHIS Vertebrate Pesticides—With the submission of reformatted zinc phosphide labels and required data, APHIS has fulfilled all of the reregistration requirements imposed by the Federal Insecticide, Fungicide and Rodenticide Act, reauthorized by Congress in 1988 for all active ingredients registered by APHIS. APHIS currently has eight active ingredients registered with EPA. These include an avian repellant (methiocarb), an avicide (DRC–1339), two rodenticides (strychnine and zinc phosphide), a fumigant (a gas cartridge that contains carbon and sodium nitrate), and two predacides (compound 1080 for use in the Livestock Protection Collar and sodium cyanide for use in the M–44).

Gas Cartridge, M–44, Livestock Protection Collar—All reregistration requirements have been met for these products. Gas cartridges are registered in two sizes for rodent and predator burrow fumigation. The M–44 is registered for controlling coyotes and wild dogs, Arctic and other species of fox, and skunks. The Livestock Protection Collar is the only registered product containing sodium monofluoroacetate. It is approved for controlling coyote depredation of

sheep and goats in several States. The user's manual and restrictions information is available on the NWRC website at www.aphis.usda.gov/ws/nwrc.

DRC–1339—APHIS has five approved labels for DRC–1339, for controlling corvids, gulls, pigeons, blackbirds, grackles, cowbirds, and starlings that damage agricultural crops, threaten public health, or prey upon threatened or endangered species. The rice and sunflower industries recently funded a confined rotational crop study with DRC–1339 to evaluate the potential uptake of DRC–1339 residues by rotational crops. Using data from this research, APHIS has submitted an application to EPA requesting that growers be allowed to harvest crops from the small acreage used in blackbird baiting programs. EPA's decision on this request is expected in FY 2001.

Strychnine—All reregistration requirements have been met for APHIS products containing strychnine. No new-use requests or cancellations occurred during FY 2000. All four registered products are for underground use to control pocket gophers. NWRC also serves as the coordinator of the Strychnine Consortium, which was assembled to generate funds to meet data requirements for all technical products.

Zinc Phosphide—APHIS maintains three zinc phosphide registrations for use on a variety of rodent species. All requirements specified in the 1998 Reregistration Eligibility Decision (RED) have been met. An application has been submitted to EPA requesting use of zinc phosphide to control deer mice around structures and to allow use on airports to reduce the rodent populations that encourage raptors near runways. This new use will also provide another tool in preventing the transmission of hantavirus from mice to humans. As with strychnine, NWRC coordinates the Zinc Phosphide Consortium to generate funds for data development of technical and end-use zinc phosphide products.

Methiocarb (Mesurol)—APHIS successfully applied for a new use for methiocarb, a very effective avian repellant. The new registration allows the use of methiocarb-treated hard-boiled eggs to protect the eggs of threatened or endangered species from predation by crows and ravens. Instead of preying on the eggs of the endangered bird species, crows and ravens eat the treated eggs and are repelled from the nesting sites of the endangered bird species.

Acetaminophen—During 1999, APHIS obtained a 3-year Emergency Use Registration from EPA to use acetaminophen as a toxicant to control the BTS on Guam. This Emergency Use Permit provides another tool to prevent the spread of the BTS to other Pacific islands. Because of the success of this compound in reducing snake numbers in baited areas, NWRC staff began during 2000 assembling the data and registration package required by EPA to support a full registration for its continued use in the Guam program.

FDA Wildlife Drug Authorizations—APHIS has five Investigational New Animal Drug (INAD) authorizations with FDA that allow interstate transport of the compounds for experimental purposes. During 2000, the NWRC Registration Unit provided 12 semiannual reports and project summaries to FDA for the INAD's. Two of the INAD's are for the immunocontraceptive materials, gonadatrophin releasing hormone (GnRH) and PZP. Studies with GnRH- and PZP-vaccinated white-tailed deer have shown both injected vaccines to be effective in reducing fawning rates. Efforts are under way to develop oral vaccine delivery mechanisms to make the techniques more appropriate for field use. During 2000, a new INAD was received to test 20, 25 diazocosterol as a reproductive inhibitor for wildlife. Recent research with the Coturnix quail, rats, and prairie dogs has demonstrated the contraceptive potential of diazocosterol. However, further experimentation with the formulation and method of administration is required. Research will continue to determine the feasibility of using diazocosterol in seasonally breeding rodents.

The remaining two INAD's are for the immobilizing agents propiopromazine HCl and alpha–chloralose. Alpha–chloralose continues to be used experimentally for capturing and relocating problem birds in urban settings, such as parks and zoos. Propiopromazine HCl (in the Tranquilizer Trap Device) is used in conjunction with soft-catch traps and has been effective in minimizing injury to trapped predators throughout the Western United States and to feral dogs on Guam.

Regulatory Assistance Provided to Federal, State, and Nongovernmental Organizations—WS program personnel or other government and nongovernment cooperators often contact the Registration Unit for information when preparing environmental assessments, environmental impact statements, and Section 7 consultations with FWS. NWRC is the principal supplier of these data to the WS program and its cooperators. Often, responses to these inquiries entail preparing unique summaries and interpretations of NWRC research. More than 100 significant requests were handled in 1999 by NWRC; most required unique responses.

NWRC staff is providing technical assistance to a consortium of State, Federal, and nongovernmental organizations in Hawaii by developing a registration package and risk assessment for registering aerially delivered anticoagulant rodenticide (diphacinone) to control rats in conservation areas. These efforts are designed to lower rat populations and reduce rat predation on forest nesting birds. Submission of this registration request is expected in 2002.

Registration Information Transfer—With the cooperation of headquarters staff, the Registration Unit completed a Webpage (www.aphis.usda.gov/ws/nwrc/RegUnit.htm) that provides copies of APHIS vertebrate pesticide labels. This service will provide WS operation staff access to the most current EPA-approved labels for all APHIS products as well as descriptions of current research activities on products authorized by the FDA under INADs.

The Registration Unit continues to maintain three pesticide and drug registration data bases. The Pesticide Registration File data base provides information on the status of individual data requirements for all APHIS vertebrate pesticides. A cross-referenced bibliographic data base has been developed that contains all known citations of published and unpublished information on 22 pesticides and drugs of interest to the WS program.

In addition, NWRC personnel continue to develop a DRC (Denver Research Center) Number database. This searchable database contains DRC numbers, chemical names, and Chemical Abstracts Service registry numbers for 6,800 chemicals that were screened for toxicity and repellancy between 1960 and 1987 by NWRC for pesticidal properties. Final preparations are under way to publish the contents of this database. Additionally, the entire database will be posted to the NWRC Website in a searchable format. Both the publication and Website are expected to be available during 2001.

PROVIDING WILDLIFE SERVICES

Goal: Provide high-quality wildlife damage-management services for our customers that result in the protection of agriculture, wildlife and other natural resources, property, and human health and safety.

NATIONAL SUPPORT

Pelican Trapping—During March 2000, a biologist from NWRC's Starkville, MS, field station traveled to east central Baja California, Mexico, with a professor and seabird ecologist from the University of California at Davis to survey pelicans. The NWRC biologist provided training on the use of modified padded leghold traps to live-capture pelicans, herons, and cormorants. These techniques and traps will be used to capture brown pelicans nesting on islands in the Sea of Cortez for a satellite telemetry study to determine their movements. This information will enable managers to better understand pelican ecology and devise an integrated, ecologically based plan for managing pelican depredations on aquaculture farms in the Southeastern United States.

National Audubon Society Christmas Bird Count—Several members of NWRC's Sandusky field station participated in the annual National Audubon Society Christmas Bird Count (CBC) in northern Ohio in December 1999. Each CBC consists of a 1-day inventory of all birds by species and numbers observed within an area defined by a 24-km diameter circle. More than 2,000 CBCs, some going back to the early 1900s, are conducted in North America during the 2-week Christmas season each winter. The data, compiled into a data base by the Cornell Laboratory of Ornithology, provide a valuable source of information on population trends, migration patterns, and winter ranges of birds throughout North America. This information is frequently used by NWRC scientists to help understand and resolve various conflicts between migratory birds and humans. This is the 21st year that NWRC biologists have participated in the Firelands CBC.

Aviation Accident Investigation Committee—At the request of a Federal transportation agency, a scientist at NWRC's Sandusky field station served during 1999 on an accident investigation committee to examine the increasing problem of aircraft collisions with wildlife (wildlife strikes) and make recommendations for actions to reduce these strikes. This investigation was precipitated by two incidents in 1999 in which two-engine commercial jetliners encountered flocks of birds (snow geese and starlings) that damaged both engines on each aircraft.

In a final report issued November 19, 1999, nine recommendations were made to the Federal Government as an integrated approach to reduce wildlife strikes and minimize the likelihood of the loss of a commercial jetliner:

1. Evaluate the potential for using radar to provide civil air traffic control personnel and flight crews with near real-time warnings of bird migration and movement activity (Avian Hazard Advisory System).

2. Coordinate with NWRC to conduct research to determine the effectiveness and limitations of existing and potential bird hazard reduction techniques.

3. In consultation with USDA's WS program, require that wildlife hazard assessments be conducted at all airports that must be certified for commercial traffic (14 Code of Federal Regulations, Part 139) where such assessments have not been done.

4. Require the development of wildlife hazard-management programs for all airports determined to need one as a result of wildlife hazard assessments proposed in recommendation 3 above.

5. Ensure that the wildlife hazard-management programs are incorporated into airport certification manuals and periodically inspect the progress of the programs.

6. Require all airplane operators to report wildlife strikes to FAA (reports are now voluntary).

7. Contract with an appropriate agency to identify bird strike remains (presently, about 50 percent of reported bird strikes do not provide any information on species struck).

8. Before allowing high-speed, low-level aircraft operations, evaluate the potential risk of increased bird-strike hazards to air carrier turbojet aircraft.

9. With representatives from USDA and various Federal agencies, establish a permanent bird-strike working group to facilitate conflict resolution and improve communication among aviation safety agencies and wildlife conservation interests.

Brown-Headed Cowbird Roundup— Biologists at the NWRC's Sandusky field station captured 400 brown-headed cowbirds in April 2000 that were used in the cooperative recovery effort for the endangered Kirtland's warbler in Michigan. The cowbirds trapped in Ohio were taken to Michigan and used as decoys to lure other cowbirds to traps in areas of jack pine forest where warblers nest, thereby reducing the incidence of nest parasitism.

The 400 decoy birds resulted in 4,345 cowbirds being captured in Kirtland's warbler nesting habitat during May through July 2000. About 117,000 cowbirds have been removed from the warbler nesting area since the trapping program began in 1972. Since 1972, cowbird parasitism has been reduced from over 50 percent to less than 5 percent of nests, and the nesting population of warblers has increased from about 180 to more than 800 pairs.

One shortcoming of the trapping program has been that about 55 percent of the birds captured were males (65 percent in 2000). NWRC is presently designing a study in cooperation with FWS to evaluate methods to increase the capture rate for females. NWRC has provided FWS with cowbirds for this endangered species project annually since 1980. Various local environmental groups and State and Federal agencies were involved in this project.

Double-Crested Cormorant Environmental Impact Statement—A research wildlife biologist from the NWRC's Starkville field station and a WS Operational Support Staff Officer in Riverdale, MD, participated in the planning meeting for developing the double crested cormorant environmental impact statement (EIS). Although FWS is the lead agency responsible for the cormorant EIS, these WS representatives provided valuable inputs as the EIS management alternatives were developed in July 2000 in Arlington, VA. The cormorant EIS will enable FWS and WS to collaboratively evaluate various alternatives associated with the management of double crested cormorant impacts to commercial and recreational fisheries throughout the United States.

INTERNATIONAL COOPERATION

NWRC–German Forest Research Collaboration—Damage inflicted by ungulates and rodents upon forest resources in Europe is similar to that found in the United States. At the request of German university faculty members, an NWRC scientist visited the university and discussed possible collaboration. The scientist toured the campus and discussed training for students interested in forest sciences. Wildlife damage issues are taught as a significant part of the university curriculum. There was also an exchange of information on current research activities to develop methods to protect forest resources at the German university and at the NWRC Olympia field station. A plan was developed for selected German students to work in conjunction with NWRC to gain practical research experience. Possibilities were also discussed that could provide for a specialized curriculum at the German university that would permit wildlife damage-management students to conduct master's degree research with NWRC.

NWRC–Mexico Airport Collaboration—A scientist from NWRC's Sandusky field station made his fourth trip to Mexico in November–December 1999 to assist aviation and university officials in evaluating bird hazards at existing airports and at proposed sites for a new airport.
Bird species hazardous to aviation (such as waterfowl, raptors, and vultures) are common in the Mexico City region, and the Mexican Government wants to ensure that the existing MCIA and the proposed new MCIA are designed and managed to minimize attractiveness to birds.

The NWRC biologist conducted a bird population census in wetland, agricultural, and landfill areas throughout the Mexico City Valley and made recommendations that would both minimize bird strike hazards at the proposed airport sites and develop and enhance important wetlands away from the proposed sites. In addition, he also surveyed and made recommendations for reducing wildlife hazards at airports in Guadalajara and Los Mochis.

Such advance planning and surveys are essential for developing environmentally sound and efficient bird-hazard reduction programs for airports. Bird–aircraft collisions cost the aviation industry well over $1 billion annually worldwide. Bird strikes are of particular concern in Mexico City because of the high elevation (about 7,400 ft) of the existing and planned airport sites.

VALUING AND INVESTING IN PEOPLE

Goal: Promote an organizational culture which values and invests in our people to support their professionalism, competency, and innovation as Federal leaders of wildlife damage management.

WS Administrative Employee of the Year—Betsy Marshall, program support assistant at the NWRC Sandusky field station, received the WS Administrative Employee of the Year award at APHIS headquarters in Riverdale, MD, in July. The award, given by the acting Deputy Administrator for WS, was presented for Marshall's critical contribution in financial and administrative management and for the extra effort she has displayed in activities such as Bird Strike Committee–USA that have promoted WS programs to reduce wildlife hazards at airports nationwide.

Cross-Training in Business for an NWRC Scientist—Dr. John J. Johnston, a supervisory research scientist at the Center, has completed a Master's in Business Administration at CSU. Coursework for this 2-year evening program encompassed project management, strategic management, accounting, finance, information technology, regulatory issues, team leadership, and marketing. This opportunity was facilitated by the WS "flex time" work schedule, the proximity of NWRC to the CSU campus, and the ability of NWRC employees to take six free credits per year at CSU. Through management's support and investment in employee growth, NWRC gained current knowledge and skills in a wide variety of pertinent areas.

The Jack H. Berryman Institute Awards—On March 6, 2000, the Jack H. Berryman Institute for Wildlife Damage Management at Utah State University, Logan, UT, presented its 1999 awards at the Nineteenth Vertebrate Pest Conference in San Diego. The Research Award went jointly to NWRC's Dr. Michael Jaeger and Dr. Dale McCullough of the University of California (UC) at Berkeley for a series of studies that demonstrated the effectiveness of reducing coyote depredation by selectively removing the specific coyotes that kill sheep. Field research was conducted by UC–Berkeley graduate students at the UC–Hopland Research and Extension Center between March 1993 and September 1998.

This annual, national award provides recognition based on recommendations of wildlife professionals throughout the United States. Two other NWRC scientists, Drs. Larry Clark and Richard Dolbeer, have received the award since its inception in 1994.

Degree Recognition—David Goldade, an NWRC chemist and a Ph.D. candidate in the Department of Environmental Health at CSU, received first place recognition for his presentation "Evaluation of Potential Capsaicin Contamination of Maple Sap and Syrup" at the American Chemical Society Agrochemical Division graduate student research competition at the Society's national meeting in Washington, DC, in September 2000. The research is a collaboration between NWRC and the WS Operations Vermont–New Hampshire office.

Goldade's research investigated the potential for capsaicin contamination of maple sap when the sap collection tubing is coated with "hot sauce paste" to deter damage caused by gnawing rodents. The research indicated that the careful selection of tubing type is essential to minimize the probability of contamination.

Publication Recognition—The NWRC 1999 Publications Awards were given to the following journal articles:

Knowlton, F. F.; Gese, E. M.; Jaeger, M. M. 1999. Coyote depredation control: an interface between biology and management. Journal of Range Management 52(5): 398–412.

Sacks, B. N.; Blejwas, K. M.; **Jaeger, M. M.** 2000. Relative vulnerability of coyotes to removal methods on a Northern California ranch. Journal of Wildlife Management 63(3): 939–949.

These two publications are excellent examples of the scope and quality of research being done by Center scientists to address a variety of wildlife damage-management issues.

INFORMATION AND COMMUNICATION

Goal: Collect and analyze internal and external information to monitor and enhance program effectiveness. Communicate internally and externally to accomplish our mission and to build an understanding of the Federal role in wildlife damage management.

INFORMATION SERVICES

Information Transfer—Information Services staff developed an automated audiovisual equipment reservation system for Fort Collins employees and began recording videotaped inhouse seminars on CD–Rom for distribution to field stations. A systematic revamping of NWRC's research project Webpages was also begun. Besides the Information Services page, the most notable additions include descriptions and photos of current Bird Research Program projects, detailing of NWRC's immunocontraception work, and full text of NWRC-authored 2000 publications. Work has also continued on developing the curriculum and Internet-based materials for the Living with Wildlife Institute for teachers and the distribution of the "Living With Wildlife" activity sheets for children.

Information Services staff members were responsible for the facilities and audiovisual arrangements for the Human Conflicts With Wildlife: Economic Considerations symposium and numerous other seminars held at the Center.

NWRC Archive—Highlights of the year include the addition of material to the unpublished reports collection and a reboxing effort to preserve these items. Beginning in summer 2000 and continuing through December 2000, a CSU public history student intern has been inventorying and reorganizing the International Program records collection. NWRC's International Program ran from 1967 to 1995, and the records contain reports, correspondence, and program material. Reorganization will greatly increase accessibility of this important research information. Also, archive staff began a project to feature NWRC history in a monthly format on the Center's Website and the employee lunchroom bulletin board. Topics reflect past programs and personnel.

Library—In FY 2000, NWRC library staff continued to introduce new electronic services to patrons and add new material to the library catalog. More than 60 items, representing almost 40 percent of the cataloging backlog, were processed into the catalog. Additionally, 120 chapters of the Birds of North America were cataloged and made accessible to patrons. Journals once again threatened to overtake available empty space on shelves. The accumulated runs of more than 100 journal titles were shifted to relieve congestion in certain parts of the library. Journal issues for most titles, years 1993–99, were sent to a bookbinder for collation into annual volumes.

To streamline interlibrary loan processes, the library instituted use of the OCLC's Interlibrary Loan Fee Management System and the Interlibrary Loan Management Statistics System. The former automates payment of any incurred interlibrary loan fees. The latter compiles monthly statistics for use by the NWRC Library in maintaining compliance with copyright guidelines and for use in quantifying the number and type of transactions completed. The library also purchased WebZap™, which, when fully automated, will allow WS personnel to file requests for books and photocopies electronically.

Copies of the NWRC Research Update, Publications List, and annual highlights report were distributed. Several hundred copies of the publication "Symposium on Double-Crested Cormorants: Population Status and Management Issues in the Midwest" were mailed, and the full text of the publication was added to the NWRC Website.

The Information Services Webpage was redesigned and enhanced. Purchase and implementation of Reference Web Poster™ software allows all Website visitors to search ProCite™ databases available in the library. The searchable databases include the 1st through the 18th Proceedings of the Vertebrate Pest Conference (fully subject indexed), the 1st through the 7th Proceedings of the Eastern Wildlife Damage Control Conference, the 1st through the 13th Great Plains Wildlife Damage Control Workshop Proceedings (partially subject indexed), the 1st through the 8th Proceedings: Bird Control Seminar, and the Annotated Bibliography of Bird Hazards to Aircraft.

GLAS™ Access software now allows Web access to the library online catalog, including the main collection and an unpublished reports file. Search tips have been custom designed for easier use. The library journals listing is available from the new Information Services page, as are NWRC's publications listings. Direct links to the Wildlife Worldwide data base, as well as UnCover™, Agris™, Agricola, and Grateful Med databases (the latter four, searchable at no cost) are also provided. A trial link to OCLC's First Search databases is available for Fort Collins personnel. Updated descriptions of the NWRC Library, Archives, and overall function of the Information Services unit have been added. New reference links are available to aid staff in location of useful sites.

SEMINARS

During 2000, NWRC continued to be a focal point for interesting seminars by its own and visiting scientists. Twenty-six individuals spoke on such subjects as coyote behavior, best management trapping practices, wildlife diseases, conservation genetics, wildlife reproductive inhibitors, animal care and research issues, aquaculture, and State agency wildlife damage-compensation programs.

NWRC SEMINARS

Speaker	Affiliation	Title
Mike Jaeger	NWRC (Berkeley)	R&D of Effective, Socially Acceptable Approaches to Coyote Management
Brian Mitchell	UC–Berkeley	Factors Affecting Responses of Alpha Coyotes to Broadcast Calls
Samara Trusso	International Association of Fish and Wildlife Agencies	Developing Best Management Practices for Trapping in the United States
Richard Duke	University of Colorado Health Sciences Center, Ceres Pharmaceuticals	Vaccines That Target Antigen Presenting Cells
Terrell Salmon	UC–Davis	Anticoagulant Baiting Strategies for California Ground Squirrels
John Pape	Colorado Division of Public Health (Denver)	Zoonotic Disease: What's Waiting in the Woods?
Eric Gese	NWRC (Logan)	Field Research on Predator Ecology
Dale Nolte	NWRC (Olympia)	Overview of the Olympia Field Station: Wildlife and Protecting Forest Resources
Brian Dorr	NWRC (Starkville)	The Great Blue Heron and Aquaculture: Changing Perspectives
Brad Blackwell	NWRC (Sandusky)	Recent Work at the Ohio Field Station: Evaluating New Taste and Visual Avian Repellants
Will Pitt	NWRC (Logan)	Modeling of Coyote Population Dynamics
Mike Avery	NWRC (Gainesville)	Overview on Research at the Florida Field Station

NWRC SEMINARS CONT'D

Speaker	Affiliation	Title
Jack Rhyan	NWRC (Ft. Collins)	Wildlife and Domestic Animal Interactions: Infectious Diseases of Concern
Peter Savarie	NWRC (Ft. Collins)	Overview of Brown Tree Snake Toxicant Research
Christen Williams	Forestry and Natural Resources, Purdue University	Molecular Tools for Managing Wildlife Populations
Christopher Walker	Uppsala University, Sweden	Conservation Genetics...Conservation Biology
J. Andrew DeWoody	University of Georgia, Genetics Department	The Natural History of Fish Mating Systems: A Genetic Perspective
Grant Singleton	Commonwealth Scientific and Industrial Research Organization, Australia	Immunocontraception, Trap-Barrier Systems and Farmer Participatory Research—Rodent Tails From Down Under
Steve Porter	Colorado Division of Wildlife (CDOW)	Managing Wildlife Damage in Colorado: Overview of the CDOW Program
Al Dale	NWRC (Ft. Collins)	Integrating Animal Care and Research Needs
Edward Schafer	NWRC (Ft. Collins, retired)	Review and Status of DWRC Toxicant and Repellant Screening Tests—25 Years of Agent Testing
Jim Glahn	NWRC (Starkville)	A Strategic Plan for Managing Cormorant Damage to Southern Aquaculture
David R. Anderson	CSU, Fishery and Wildlife Biology Department	Perspective on How Science Might Be Done in the Next Century
Earl Campbell	NWRC (Hilo)	Trouble in Paradise: Invasion of Hawaii by Alien Frogs
David Goldade	NWRC (Ft. Collins)	Biotransformation of 3-Chloro-p-toluidine Hydrochloride (CPTH)
Simon C. Nemtzov	Israel Nature and Parks Authority, Science and Conservation Division, Jerusalem	An Israeli Success Story: Conflict Resolution and Conservation of the Endangered Pygmy Cormorant *(Phalacrocorax pygmeus)*

MEETINGS, WORKSHOPS, AND CONFERENCE PRESENTATIONS

Fifteenth Annual Airport Conference— This conference, held in Chicago in November 1999, was attended by about 400 representatives from throughout the aviation industry. During the keynote address, Captain Dennis Dolan, first vice president of the Air Line Pilots Association, highlighted bird strikes as a key safety issue facing the aviation industry. Topics covered by NWRC scientists included the development, management, and uses of the National Wildlife Strike Database, new wildlife management tools for airports such as a recently registered anthraquinone formulation to repel geese, and production of a 300-page manual on wildlife hazard management for airports that was distributed to airports nationwide in December 1999. NWRC personnel also had an exhibit at the conference that promoted WS research and management programs at airports. NWRC's research on these topics is funded in part by Federal agencies, private industry, and various airport authorities through interagency and cooperative agreements.

USDA Forest Service Silvicultural Team Visits—NWRC's Olympia, WA, field station hosted the silvicultural team from the USDA Forest Service's Pacific Northwest Forest and Range Experiment Station on July 5. A group of 18 Forest Service specialists toured the facilities and discussed current and past research activities with field station personnel. NWRC staff provided an overview of the biology and behavior of the wildlife species that damage timber resources and discussed ongoing efforts to alleviate forest damage, as well as research projects being conducted to develop new techniques, to improve the efficacy of existing techniques, and to obtain information on the environmental effects of forest protection practices.

The silvicultural team saw mountain beaver, beaver, and deer within different habitat-use pen research facilities and discussed recent studies of bear activity in the vicinity of supplemental feeding stations that are used in some areas to reduce bear girdling of trees after emergence from hibernation.

NWRC has worked closely with the Forest Service to develop methods to reduce the problems encountered when establishing trees for reforestation, improving species diversity, restoring riparian habitats, or for protecting areas where regeneration or spread of natural timber stands have been impeded by foraging animals.

Electric Utility Consultation—An NWRC researcher was invited by an electric utility construction company to participate in a discussion of woodpecker damage to wood utility poles in June. The discussions centered around the extent of woodpecker damage to utility poles and the potential products for prevention, control, and repair of woodpecker damage to them. The group also identified three potential research areas: repellants, coatings, and habitat management.

NWRC has developed a cooperative research proposal with industry and academic groups to investigate these potential areas of research to prevent woodpecker damage to utility poles. Several additional utility companies in the Southeastern and Northwestern United States have expressed interest.

Cable News Network's Aquaculture Story—Wildlife biologists with NWRC's Starkville field station were featured on the July 13, 2000, Cable News Network (CNN) television program "Earth Matters." Along with an aquaculture industry representative from Louisiana, NWRC biologists were interviewed regarding their ongoing research associated with the impacts of fish-eating birds on southern aquaculture. In particular, the CNN story highlighted NWRC satellite telemetry research in Alabama, Arkansas, Louisiana, and Mississippi. This research has been designed to evaluate regional movements of double-crested cormorants associated with catfish depredation in these States. The CNN story was an opportunity for the international audience to understand some of the present NWRC aquaculture research activities.

Human Conflicts With Wildlife: Economic Considerations Symposium—The NWRC hosted a "Human Conflicts With Wildlife: Economic Considerations Symposium" August 1–3, 2000, in Fort Collins. In all, 25 invited speakers from the United States, New Zealand, Australia, Germany, and the United Kingdom, representing a cross section of the most knowledgeable authorities in the world on wildlife–human conflicts and the associated costs, addressed more than 100 participants. Symposium topics included methods for quantifying resource damage caused by wildlife and case studies of damage caused by wildlife to agricultural commodities, the costs associated with damage caused by wildlife to nonagricultural activities of humans, the costs and implementation of management programs to control the spread of wildlife–related diseases to humans and domestic livestock, optimization models as a method to allocate research and operational resources in the development of management plans, and the impact of wildlife on other wildlife as it relates to environmental management practices.

This is the third such international symposium hosted by NWRC. The previous two were titled Repellants in Wildlife Management (1993) and Contraception in Wildlife Management (1995).

Aquaculture for Kids—A wildlife technician at NWRC's Starkville field station recently presented a "Living With Wildlife" information seminar to 200 elementary school children in July. The technician described problems associated with piscivorus birds feeding at catfish and bait fish farms in the Southern United States and gave an overview of research techniques used to study these birds and how research helps alleviate these conflicts. The children viewed a slide presentation, NWRC posters, and various equipment used to study wildlife (e.g., telemetry, traps, and bands) and were given "Living With Wildlife" materials.

Bird Strike Committee–USA/Canada—About 400 people from 15 countries attended the second annual joint meeting of Bird Strike Committee–USA (BSC–USA), and Bird Strike Committee–Canada at Minneapolis–St. Paul International Airport in August. The meeting was organized by NWRC Sandusky field station biologists in cooperation with several aviation groups and WS personnel from Minnesota. In all, 37 technical papers and posters were presented on topics related to reducing wildlife collisions with aircraft.

Among highlights of the conference were presentations by representatives from several Federal transportation agencies regarding their recommendations to reduce wildlife hazards on airports. Another highlight was the demonstration of various techniques for managing wildlife on airports during an all-day field trip to two airports. Fifteen companies exhibited their wildlife management products or services.

The goal of BSC–USA is to increase communication and professionalism among the diverse groups dealing with wildlife issues on airports, and the 2000 meeting appeared to be highly successful in this regard. WS biologists played an increasingly important role in reducing wildlife hazards at U.S. airports in 1999, providing assistance at 363 airports. About 70 WS biologists attended the meeting.

Third International Symposium and Workshop on Frugivory and Seed Dispersal—A scientist from the NWRC's Gainesville, FL, field station attended the third International Symposium and Workshop on Frugivory and Seed Dispersal during August, in São Pedro, Brazil. The scientist presented a plenary talk on reducing bird damage to cultivated fruit. The conference was attended by about 300 persons from 30 different countries.

Taming the Wild Stuff—The Society of American Archivists held its annual meeting in Denver from August 31 to September 2. The sessions concerned various archival and records management issues. In addition, plenary speakers provided insight into the future of the archival field and the value of diversity. The NWRC Records Manager/Archivist participated in a panel on material culture. A slide presentation, "Taming the Wild Stuff," detailed using material culture as exhibit and educational instruments. NWRC's material culture includes the tools used in research and damage control work, and these items are important historical artifacts.

Mississippi Wildlife Services State Meeting—Wildlife biologists from the NWRC's Starkville field station made several presentations at the Mississippi WS State meeting, at Plymouth Bluff, MS, in August. The presentations provided an overview of the Mississippi field station's recent research on double-crested cormorant and great blue heron depredations on aquaculture in Mississippi. The talks focused on nonlethal avian dispersal techniques such as the use of laser light at cormorant roosts, economic impacts and management recommendations concerning great blue heron depredations on catfish aquaculture, and satellite telemetry research regarding regional and migratory movements of cormorants. The presentations demonstrated that information developed from this research is used to design specific tools and management recommendations that can be used by NWRC's stakeholders.

Lower Mississippi Valley Joint Venture North American Waterfowl Management Team—A wildlife biologist from the NWRC's Starkville field station met with members of the Lower Mississippi Valley Joint Venture North American Waterfowl Management Team in Vicksburg, MS, in August. Members of the team included waterfowl researchers from Federal agencies and private organizations. The meeting was arranged to address aerial and ground survey issues concerning future research on double-crested cormorant populations and their distribution on catfish aquaculture in the Mississippi delta. The proposed research will be integrated with ongoing satellite telemetry research to address questions concerning use of aquaculture, migratory patterns, population estimation, and population turnover of double-crested cormorants in the Southeast.

Symposium Adjunct to the Wildlife Society's Annual Meeting—WS, The Humane Society of the United States, and the Jack Berryman Institute cosponsored a symposium entitled "Nonlethal Approaches to Wildlife Damage Management: Promise, Potential, Reality" at the national meeting of the Wildlife Society in Nashville in September. There were 14 presentations by leading scientists (including 3 from NWRC), administrators, and practitioners in the field of wildlife damage management. Issues discussed included the efficacy and humaneness of relocation of nuisance wildlife to resolve conflicts, the effectiveness of various exclusion devices, situations where lethal control is justified, and the potential for reproductive inhibitors. The symposium was successful in promoting constructive dialogue that should lead to greater cooperation among the various governmental and private groups dealing with the growing diversity of wildlife–human conflicts.

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